Monuments Above The Water: Montana's Historic Highway Bridges, 1860-1956

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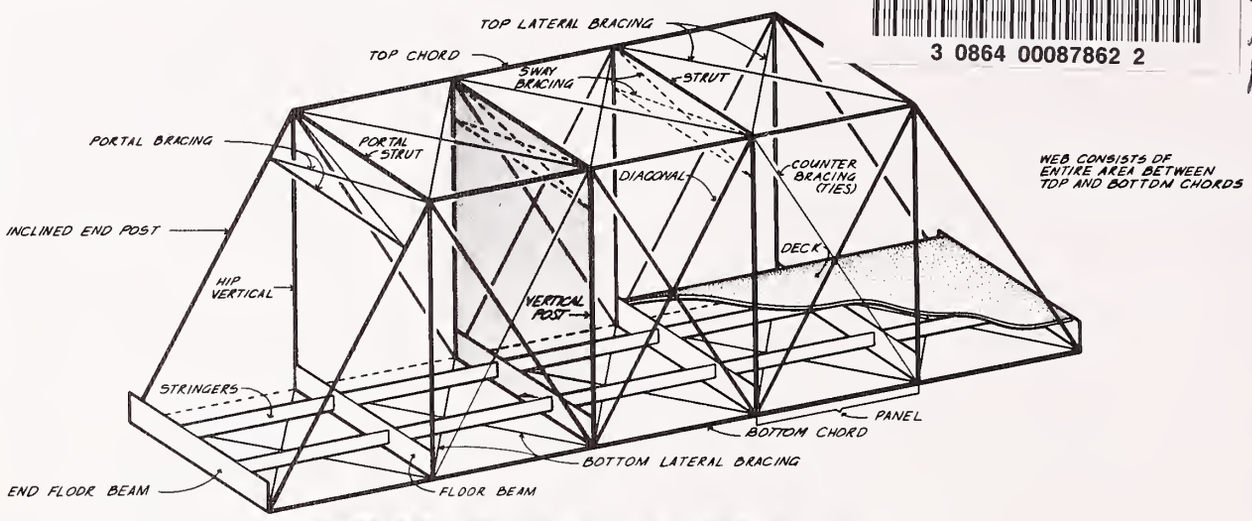
1993



WEB CONSISTS OF ENTIRE AREA BETWEEN TOP AND BOTTOM CHORDS

TRUSSES

A STUDY BY THE

HISTORIC AMERICAN ENGINEERING RECORD

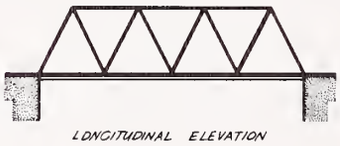
A TRUSS IS COMPOSED OF STRUCTURAL TRIANGLES JOINED TOGETHER WITH PINNED OR RIVETED CONNECTIONS. THE MAIN PIECES OR MEMBERS MAY BE EITHER STIFF HEAVY STRUTS, RODS OR THIN FLEXIBLE BARS. IT IS THE ARRANGEMENT OF THESE MEMBERS THAT DETERMINES THE SPECIFIC TRUSS TYPE.

STRUCTURAL MEMBERS RESIST FORCES IN TWO PRIMARY WAYS — COMPRESSION AND TENSION. HEAVY RIGID MEMBERS MAY RESIST BOTH COMPRESSIVE AND TENSILE FORCES, BUT THIN RODS CAN ONLY RESIST TENSION AND THESE CHARACTERISTICS ARE MAJOR CLUES IN TRUSS IDENTIFICATION. NOTE THAT THE MAIN STRUCTURAL MEMBERS OF A TRUSS PANEL MAY BE SUPPLEMENTED BY THIN DIAGONAL TIES. BECAUSE TRUSS TYPES ARE DETERMINED BY THEIR MAIN STRUCTURAL MEMBERS, THESE COUNTER BRACES (INDICATED BY BROKEN LINES, ON THE IDENTIFICATION SHEET) MAY BE IGNORED. AFTER MATCHING THE STRUCTURAL OUTLINE OF THE TRUSS IN QUESTION WITH THE DIAGRAM IT MOST RESEMBLES, CHECK TO MAKE SURE THE ARRANGEMENT OF HEAVY COMPRESSION AND LIGHT TENSION MEMBERS IS COMPATIBLE WITH THE DIAGRAM. IF THERE IS AGREEMENT, THEN THE BASIC TRUSS TYPE IS IDENTIFIED.

THE SHEET OF TRUSS DIAGRAMS PRESENTS ONLY THE STANDARD FORMS OF THE MOST COMMON TRUSSES. THERE ARE ALSO MANY "HYBRID" TRUSSES THAT DO NOT FALL INTO EASILY-DEFINED CATEGORIES. IN SUCH CASES, IDENTIFICATION SHOULD BE MADE AS CLOSELY AS POSSIBLE IN TERMS OF THE STANDARD DESIGNS. ADDITIONALLY, TRUSSES OFTEN ARE INVERTED, CREATING OUTLINES QUITE DIFFERENT FROM THE ORIGINAL — TENSION MEMBERS BECOMING COMPRESSION MEMBERS AND VICE VERSA. BEFORE ASSUMING A TRUSS IS NOT REPRESENTED ON THE DIAGRAM, CHECK TO SEE IF IT IS AN INVERTED FORM.

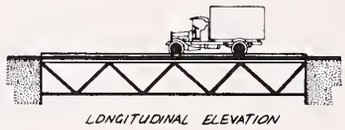
MOST BRIDGE TRUSSES ARE OF THREE BASIC TYPES. IF THE DECK AND/OR RAILS ARE LEVEL WITH THE BOTTOM CHORDS, IT IS A THROUGH TRUSS. A PONY TRUSS IS A THROUGH TRUSS WITH NO LATERAL BRACING BETWEEN TOP CHORDS. A DECK TRUSS CARRIES ITS TRAFFIC LOAD LEVEL WITH THE TOP CHORDS.

TRUSS BRIDGES



LONGITUDINAL ELEVATION

LONGITUDINAL ELEVATION



LONGITUDINAL ELEVATION

TRANSVERSE SECTION

THROUGH TRUSS

TRANSVERSE SECTION

PONY TRUSS

TRANSVERSE SECTION

DECK TRUSS

ROOF TRUSSES

FINK

THIS IS A VARIATION OF THE FINK TRUSS SHOWN IN THE BRIDGE DIAGRAM

PRATT

DIAGONALS IN TENSION

SAWTOOTH

USUALLY USED TO ALLOW NATURAL LIGHTING OF LARGE FLOOR AREAS.

SCISSORS

USUALLY USED FOR LARGE VAULTED CEILINGS

BELGIAN

DIAGONALS PERPENDICULAR TO TOP CHORDS

HOWE

DIAGONALS IN COMPRESSION

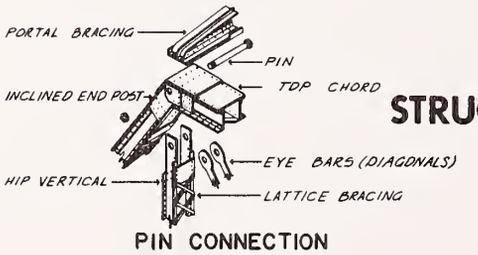
HOWE

DIAGONALS IN COMPRESSION

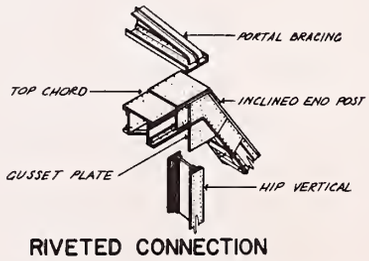
THREE-HINGED ARCH

USED FOR EXCEPTIONALLY LONG SPANS

STRUCTURAL CONNECTIONS



PIN CONNECTION



RIVETED CONNECTION

1ST PRINTING 1976; REVISED OCT. 1976

OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION TECHNICAL INFORMATION PROJECT UNDER DIRECTION OF THE NATIONAL PARK SERVICE, UNITED STATES DEPARTMENT OF THE INTERIOR	TRUSS IDENTIFICATION: NOMENCLATURE	RECORD NO. HAER TI-1	HISTORIC AMERICAN ENGINEERING RECORD SHEET 1 OF 2 SHEETS

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ACKNOWLEDGMENTS

A work of this scope required the assistance and advice of many individuals. Not all of them knew much about historic bridges at the beginning of the project--I would hope they know a lot more now.

Jack Walsh provided valuable information about bridge building at the Montana Department of Transportation. Jack was the Department's Bridge Maintenance Engineer until his retirement in 1993. Because of his responsibilities, he probably knows more about the "guts" of Montana's historic bridges than does anybody else. I owe a lot of my understanding of the subject to Jack and am grateful.

Historian Fred Quivik also provided considerable input into this volume. Fred wrote Historic Highway Bridges in Montana in 1981. It was one of the first histories of bridge building in the United States and, as far as I know, provided the model for many other similar studies. Fortunately for me, Fred was working on his Doctoral Dissertation in Pennsylvania and was unable to tackle the revised history of Montana's bridges. Thank you, Fred.

Travis Smith and Rick Shibley processed and printed the photographs that grace this study. The illustrations were provided by John Robinson and Lynn Predmore. Finally, Edrie Vinson and Mitzi Rossillon developed the agreement that resulted in this publication. Their foresight enabled the Department to start looking at historic roads and bridges as a valuable resource rather than as an impediment to progress.

Marcella Sherfy and Kathy Huppe fielded countless questions and progress reports as this volume was being researched and written. Dave Walter at the Montana Historical Society was his usual helpful self in uncovering forgotten Montana Highway Commission records without losing his good humor. Fortunately, I was able to draw on the first-hand experience of John Morrison when researching the activities of the Montana Highway Department during the Great Depression. John was the Department's worked in the Bridge Department and was responsible for supervising the design of many of the bridges that we are still using on the state's primary and secondary roads.

Finally to my wife, Lisa. She not only endured our many side trips to look at the old bridges, but also had to listen to me talk about them all the time.

INTRODUCTION

Early in the evening of December 15, 1967, metal fatigue contributed to the collapse of the Silver Bridge at Point Pleasant, West Virginia. The catastrophic failure of the 40-year old bridge took the lives of 46 persons and caused the federal government to enact a program of bridge inventories and inspections. The 1968 Federal-Aid Highway Act specified that the Federal Highway Administration (then the Bureau of Public Roads) conduct bridge inspections on all structures built before 1951. The inspections revealed that approximately sixteen percent of the 563,500 bridges located on the nation's roadways were critically deficient and in need of either rehabilitation or replacement. This Federal legislation created a new challenge for historic preservationists by forcing them to look at a resource that had hitherto been largely ignored.[1]

Unfortunately, the goals of the preservationists often clashed with the policies of the Federal Highway Administration and the state highway departments. Many important bridges were demolished before they were inventoried and their historic significance assessed. Though federal regulations required that assessments of historic significance be made before a bridge was rehabilitated or destroyed, many of the older bridges were safety hazards that required immediate replacement. Consequently, in the 1970s many states initiated historical bridge inventories to photograph and record old bridges before altered or destroyed.

In 1979, the Montana Department of Transportation commissioned an inventory of all steel truss and reinforced concrete bridges more than 45 years old and more than 20-feet long. The completed inventory included approximately 500 bridges, 77 of which were determined to be eligible for listing on the National Register of Historic Places. In 1986, the Department inventoried over 980 timber bridges--28 of which were found to be eligible for the National Register. Before long, the number of road reconstruction projects overwhelmed the cultural resource staffs of the Department and the State Historic Preservation Office. Each bridge and segment of road was evaluated for its historical significance on an individual basis. Since there were nearly 3,000 bridges of historic age both on and off system in Montana, the process was time consuming and not conducive to the preservation of the resource.

In 1989, the Department signed a Programmatic Memorandum of Agreement that abrogated their requirement to inventory all historic roads and bridges within Montana. The agreement, which is the first of its kind in the United States, requires the Montana Department of Transportation to complete narrative and technical histories of road and bridge development in the state. This document is the result of that agreement.

Until 1847, American bridge design was an empirical exercise for builders with virtually no background as professional engineers. Builders--who were most often carpenters--developed a large variety of wood trusses, often with little idea of how or why the truss worked. Although failures were common, this style of bridge design persisted until the mid-1840s. The establishment of the railroad in the 1840s created a need for reliable and durable long-span structures. The railroads necessitated the establishment of the modern science of bridge engineering in the United States. Although many of the bridge types in use today were originally developed in the 19th century, the process of improving the materials that comprise the structure has been in constant evolution.[2]

In the United States, bridge engineering has symbolized the technological and industrial development of the country. Bridge builders have been quick to adopt new structural materials and construction techniques almost as soon as the engineers developed them. For example, iron quickly supplanted wood as the primary construction component once the engineers and fabricators understood its properties. In turn, steel replaced iron when the fabricators improved the material and mass production was possible. In each case, changes in materials resulted in improvements in the structural properties of the form, allowing the construction of more massive and longer spans.

To facilitate the rapid growth of the nation's young transportation system, economy of construction and durability have also been goals of the bridge engineers. This progression in design and materials caused one early 20th century bridge engineer to observe that "Today [1916] bridge building is truely [sic] a science; only three decades back it was hardly worthy to be termed an art; while seventy-five years ago, . . . it was no better than a trade. Nearly all of the important and distinctive features of modern American bridge practice have been developed within the memories of engineers still living . . . ."[3]

From the first rudimentary timber bridges constructed by the military in the early 1860s, to the pervasive prestressed concrete bridges of the modern era, bridges have been a significant factor in the development of the Montana landscape. Montana bridge builders have, however, been conservative in their use of materials and have largely relied on already proven bridge designs. State bridge engineers have had little need to create new structural designs and materials. What resulted is a system of standardized and reliable bridges with little deviation from the standards developed in the early 1920s.

This history is essentially broken into eight sections. Five of the sections detail specific types of bridges such as timber, truss, steel, reinforced concrete and other miscellaneous bridge types present in Montana. The first section is a general overview of the history of bridge construction in Montana, including the creation and development of the Montana Highway Commission, the bridge construction companies and the massive road and bridge building programs of the 1930s. Finally, Part 8 includes specific bridges that illustrate specific structure types, special bridges and those that exemplify the development of bridge construction and design in Montana. Although a few of the bridges (i.e. the Snowden and Tenth Street bridges) included in that section have been described in Fred Quivik's excellent 1981 history, the author felt that their contribution to the subject warranted another look.

PART 1 - HISTORY

Lieutenant John Mullan constructed the earliest known bridges in northwestern Montana between 1859 and 1860. The Mullan Road was the first federally funded and engineered road in Montana. It also functioned as an emigrant road between the head of navigation on the Missouri River at Fort Benton and Walla Walla, Washington on the Columbia River. Mullan constructed approximately 47 rudimentary timber bridges across the St. Regis and Clark's Fork rivers. Within a year, however, spring run-off destroyed most of the bridges. Mullan contracted with a Deer Lodge Valley resident, Samuel Hugo, to repair and replace the bridges near the Blackfoot River. High water again destroyed many of the structures in early 1862. Because of the Civil War, however, no federal funds were available to replace the bridges.[1]

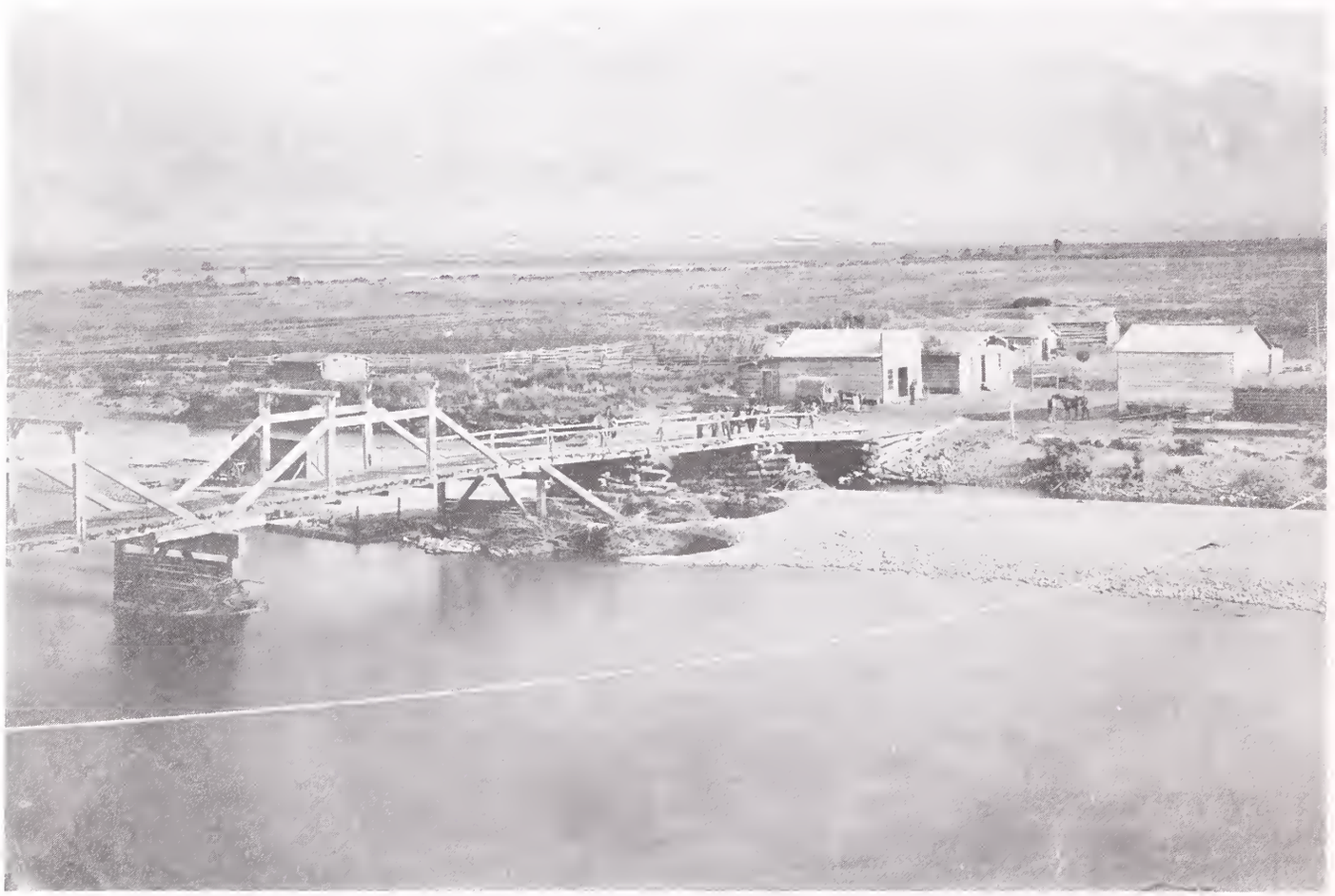
By 1866, the Mullan Road in western Montana was little more than a tangle of destroyed bridges and fallen timber. Local entrepreneurs, however, maintained the road between Fort Benton and Hellgate Canyon to take advantage of traffic resulting from the discovery of gold in the region in the 1860s. The Mullan Road was the basis of the territory's highway system; sections of the road are still in use today.

The mining camps relied on dependable systems of transportation to ensure their continued prosperity. The settlements needed good roads for the import of supplies and the export of gold from the mines. The first Montana Territorial Legislature in 1864 eagerly sought means of funding the construction of roads and bridges with virtually no tax base. Since the construction and maintenance of toll roads and bridges did not require the expenditure of public funds, the legislature licensed thirty-five private individuals and companies to construct the facilities. To receive a franchise, the licensee guaranteed to maintain the road or bridge and charge a reasonable toll for its use. If the company did not abide by the terms of the license, then the territorial governor could revoke it. Unfortunately, the contracts were seldom enforced and complaints about the poor condition of the facilities and the high tolls charged by the owners were common among users.[2]

The 1864 territorial legislature licensed seven bridge and ferry companies for the construction and maintenance of structures on the Jefferson, Big Hole and Beaverhead rivers. Most of the bridges were primitive timber structures, although not a few were more spohisticated with wood king post trusses supported by rock-filled log crib piers and abutments. Because of the capital needed to construct the bridges, the structures often existed only on paper and were never constructed by the companies. For others, the capital outlay was such that the companies charged high tolls to recoup their investment. Nonetheless, toll roads and bridges were a lucrative business to many of Montana's pioneer capitalists. Consequently, they dominated the development of Montana's road system until 1870 and provided the foundation for the state's highway system of the 20th century.[3]

Parson's Bridge was typical of the small toll bridge operations chartered by the legislature in southwest Montana during the 1860s. Built in 1865, the bridge crossed the Jefferson River near Cardwell. A. Parson initially constructed a cable ferry on the site in either 1863 or 1864. By 1865, he established a small community immediately next to the bridge on the south bank of the river. The unlicensed Crawford & Company constructed a bridge approximately five miles above Parson's Bridge in 1866. Through the *Montana Post*, the owners claimed the "Monopoly . . .

at an end" and charged smaller tolls to undercut the older bridge's business. Within a few years, however, high water destroyed the new structure and Parson's Bridge again was the sole river crossing in the area. The county constructed a steel Pratt truss bridge at the site in 1899 and the Montana Highway Department replaced it with a prestressed concrete bridge in 1961.[4]



Parson's Bridge, circa 1867 (Montana Historical Society).

Less expensive than roads and more profitable, bridges required little capital outlay and, in retrospect, relatively little maintenance. While several road companies had their charters revoked by the governor, he voided few bridge licences, suggesting that the toll bridge companies were financially sound and firmly entrenched in the territory's landscape. Freighters and lone travelers alike, however, occasionally complained of high tolls charged for the use of decrepit bridges. Although the 1866 Territorial Legislature sponsored charters for ten bridge companies, Acting Governor Thomas Francis Meagher was not empowered to grant the franchises. The 1867 and 1869 territorial legislatures revoked most the charters. The 1867 legislature, however, reinstated the charters of three companies licensed the previous year.[5]

Most toll operators maintained their bridges and charged competitive rates for their use. However, user protests about the system forced the territorial government to take action against the toll companies in 1869. The legislature repealed most of the toll road and bridge licenses in 1869. Instead, they directed the counties be given the power to regulate tolls on bridges and ferries. Although some toll facilities were exempted from the purge and allowed to remain in operation, most were appropriated or relicensed by the counties.[6]

Built about 1880, the Morelli Bridge is located on the Fort Benton-Helena Road at Reeder's Alley in Helena. The piers are stone mortared with cement. The City of Helena rehabilitated the bridge in 1974. The Morelli Bridge is the oldest bridge still in use in Montana.

The legislature organized the counties into road districts to manage road and bridge construction within their jurisdictions. The counties appointed road supervisors to oversee the construction and maintenance of roads and bridges in their districts. They also levied taxes for the maintenance and construction of roads. Citizens who could not or did not want to pay the tax could work off their debt by participating in some road-related activity.[7]

The counties, moreover, levied special taxes expressly for the construction of new

bridges. Between 1870 and 1913, the Montana government had neither the money nor the inclination to construct roads and bridges. The counties, therefore, were responsible for all the road and bridge construction in their districts. The result was a system of locally standard roads and bridges that were constructed according to the whims of the contractors rather than of the county commissioners. It is doubtful that the Legislature realized the full extent of the road and bridge system in Montana prior to the creation of the Montana Highway Commission.[8]

Although widely condemned by the public, the toll companies were important to the development of Montana's transportation system. Toll bridges provided a needed service to the economic growth and prosperity of the mining and agricultural areas of the territory. While sometimes a risky venture (both in terms of profit and the use of the structure), the bridges were a "stopgap measure when nothing else was available [and] serv[ed] a definite purpose by providing a means by which the mining districts could be reached." Today, Browne's Bridge near Glen in Beaverhead County and the Madison River Bridge east of Norris are located at crossings established as toll bridges in the early 1860s.[9]

By 1872, the legislature and counties chartered no new toll companies. The county commissioners and road supervisors initiated all road and bridge construction work. Six years later, in 1878, the territorial legislature seized control of nearly all the remaining toll facilities. If the owner had not maintained the road or bridge to the satisfaction of the commissioners, then the property was confiscated by the county. For roads and bridges that had been properly maintained with reasonable tolls, then the territorial and county governments compensated the owners of the company. By 1883, there were only two toll facilities still in operation in Montana Territory.[10]

It is not known the number or the type of bridge structures constructed in Montana between 1871 and 1883. There are few existing photographs of the bridges and even fewer descriptions of their appearance. Most references to the structures concern the owners, the condition of the bridge and the tolls. All were probably simple timber bridges similar to those constructed in the 1860s. Despite the encroachment of farmers and ranchers into central Montana, the counties continued to build highway bridges on or near already existing bridge sites in southwestern Montana. It was not until the Union Pacific Railroad entered southwest Montana near Dillon in 1881 that a major bridge-building program was initiated in the state.[11]

The railroads fueled an economic boom in mining and agriculture in Montana. While they allowed easier access to markets for the territory's industries, the railroads also enabled eastern investment in the ranching and mining industry in Montana. Between 1881 and the early 1890s, the railroads dominated the bridge construction industry in Montana. Initially, the railroads constructed simple timber trestle bridges to span the innumerable crossings within their rights-of-way. After the line was completed, however, the companies gradually replaced the wood structures with permanent iron or steel bridges.[12]

Between 1881 and 1893 the expansion of the Union Pacific, Northern Pacific and Great Northern railroads overshadowed the development of Montana's transportation system. There was, apparently, little highway bridge construction initiated by the territory until the late 1880s. Road and bridge construction remained the responsibility of the counties after Montana statehood in 1889. There were

essentially no state or federal regulations governing standards and no professional highway bridge engineers active in the state. Consequently, the county governments had no "long-range programs of improvement but were . . . governed in their actions by political influences which in some instances caused special favoritism and resulted in delayed over-all construction programs and at an excessive cost." The railroads did, however, introduce one important factor that would greatly influence the way bridges were constructed in Montana for the next twenty-five years: the bridge construction companies.[13]

Northern Pacific Railroad Bridge over the Yellowstone River near Billings, 1894 (Haynes Foundation Collection. Montana Historical Society).

The Bridge Construction Companies

Between 1883 and 1915, Midwest-based companies dominated bridge construction in Montana. Although important to the early development of Montana's roadways,

problems with the bridge companies was partially responsible for the creation of the Montana Highway Commission in 1913. The history of the bridge companies, however, dates to the development of the bridge truss in the early 19th century.

The first bridge-construction companies were formed in the eastern and midwestern United States about 1850 to build truss bridges for the railroads. Even without the services of qualified bridge engineers, the firms flourished because of their proximity to the railroads and the great demand for new bridges. Through either the purchase of bridge patents or with their own designs, the companies marketed their bridges through catalogs and agents strategically placed in communities located along the railroad mainlines. The increase in the number of bridge companies active in the Trans-Mississippi West corresponded with the expansion of the iron industry and the completion of the first transcontinental railroad in 1869.[14]

After the county commissioners selected a bridge design, the company assembled the bridge in the factory, marked the components dissembled the bridge, and then shipped the parts to the construction site. Often, an "expert" accompanied the dissembled bridge to the site to supervise its construction. The on-site assembly of the bridge, however, was often done with unskilled labor. Nonetheless, the completion of the bridge was cause for community celebration and pride since it symbolized the social stability and prosperity of the area. With the creation of state highway departments and the standardization of bridge designs in the early 20th century, the bridge companies were eventually replaced by local contractors.[15]

Since their knowledge of bridge design and construction was limited, the county commissioners sacrificed good bridge designs in the interest of economy. Graft and fraud were rampant in the industry as fierce competition frequently pressured the more reputable firms to cut corners. Because of the lucrative nature of the industry, the contractors (and, occasionally, the commissioners) sometimes engaged in "pooling" or collaboration with the bridge companies to allow only certain firms to operate in a given area--and at a given price. This not only guaranteed a market for the product, but also the amount of money the county paid for the bridge. By the second decade of the 20th century, however, one critic claimed that,

> This loose method of contracting for bridges makes it practically impossible for even honest officials to procure a satisfactory structure and opens up the way for dishonest officials and contractors to arrange a deal whereby the public comes out second best . . . . It has made it possible for "fake bridge companies" to exist and also for crooked public officials to receive part of the profits of the transaction. It has uniformly resulted in high prices and poor bridges.[16]

There is some indication that "pooling" occurred in Montana. The Missoula-based O.E. Peppard Company was primarily active in western Montana, while the Security Bridge Company's projects appear confined to south central and southeastern Montana. Although there are a few examples of truss bridges that were not assembled correctly, the bridge companies performed a valuable function in the early development of the state's transportation system. The distrust by professional bridge engineers and the public was such, however, that it eventually led to the regulation of the industry.

Dedication of Forsyth Bridge, 1905 (Montana Department of Transportation).

County-contracted builders dominated highway bridge construction after the completion of the Great Northern Railway in 1892. The completion of the railroad, however, allowed the bridge companies headquartered or with branch offices in Minnesota to move into Montana. In the 1890s, the industrial/urban centers of western Montana provided the initial markets for the bridge companies. Based on the surviving structures, evidence suggests that the companies initially built large numbers of steel truss bridges in Silver Bow, Deer Lodge, Gallatin, Jefferson, Lewis and Clark and Cascade counties.[17]

The first companies to become active in Montana were the San Francisco Bridge Company, the Milwaukee Bridge and Iron Works and the Cleveland-based King Bridge Company. There are sixteen bridges still located on Montana's secondary and off-system roadways that date from that period of initial construction activity (the King Bridge Company built seven bridges). Most of the bridges were simple

Pratt truss structures with minor variations typical of most structures constructed by the bridge companies.

During the late 1890s, the Good Roads Movement gained momentum in the East to promote the construction of roads and bridges. In Montana, the movement to promote good roads manifested itself about 1900 and resulted in the creation of the Montana Good Roads Congress. Dominated by farmers, ranchers and bicyclers, the group advocated the construction of farm-to-market roads. This, they believed, would result in the "autonomy and self-sufficiency" of rural communities and promote tourism. The Congress also encouraged the counties to assume greater responsibility for bridge construction and enlisted the broad-based support of the state's middle class. They also advocated the establishment of a highway commission to standardize road and bridge construction. The counties, however, continued to rely on the private bridge companies. By 1900 the number of bridge failures on the nation's highways surpassed those of the railroads and the public movement to regulate the bridge industry increased.[18]

There were approximately forty bridge construction companies active in Montana between 1890 and 1920. The county governments, however, depended on the Minnesota bridge companies because of their direct access to the railroads that traversed Montana. The most prominent of these were the Gillette-Herzog Manufacturing Company, the American Bridge Company, Hewett Bridge Company and the Minneapolis Steel and Machinery Company. Two Montana-based companies--the Security Bridge Company and O. E. Peppard--also operated in Montana.

Because of the phenomenal growth in Montana's economy in the early 20th century, competition between the bridge companies was intense. Many of the companies counted on the inexperience of the new county governments to help sell bridges. Most county commissioners were unaware of the local traffic needs and did not have the necessary resources to check the structures once completed. Despite the marketing, political and construction shenanigans that may have occurred prior to World War I, no bridge constructed by a bridge company in Montana has, as yet, failed because of its design.[19]

The Gillette-Herzog Manufacturing Company was founded in Minneapolis in 1890. Shortly after the completion of the Great Northern Railway in 1893, the company moved into Montana and opened a branch office in Butte (the company also built steel mine headframes). Gillette-Herzog, like most other bridge builders, favored Pratt truss bridges. The company built the Old Steel Bridge in Flathead County near Kalispell in 1894. The structure cost $17,497 and was the first major bridge constructed in northwestern Montana. Before the Gillette-Herzog company merged with 23 other bridge companies to form the American Bridge Company in 1900, it built many steel truss bridges in Montana--eight of which survive.[20]

The Security Bridge Company was an active Montana-based bridge company. Founded in 1906 by William S. Hewett and his cousin, Arthur, the organization built at least 32 bridges in the state between 1906 and when it ceased operations in 1925. The company was the progeny of the Minneapolis-based Hewett Bridge Company. The Hewetts established a branch office of the firm in Billings in 1904, before organizing the Security Bridge Company two years later. Even after the creation of

the Security Bridge Company, however, the new business continued the policies and maintained the personnel of the parent company.[21]

The most prominent of the Montana-owned firms was O. E. Peppard of Missoula. Peppard acquired his bridge building expertise while employed by the Northern Pacific Railroad in the 1880s and 1890s. He was responsible for the construction of the bridges on the Bitterroot and Phillipsburg railroad branchlines before he established his own construction company. By the mid-1890s, he had constructed a number of bridges in Deer Lodge and Missoula counties. While Montana's economy expanded during the first two decades of the 20th century, Peppard constructed over 27 bridges in the state between 1907 and 1916.[22]

The United State's entry into World War I caused a slowdown in the number of truss bridges built in the state. The foundries manufactured steel to support the war effort overseas and were little concerned about the domestic market. Peppard gradually turned away from bridge construction to the sale of farm implements. The shift away from bridge construction symbolized the industry in the post-war years. The Montana Highway Commission's stringent design standards, economic depression and inflation caused a decline in the number of large structures built in the state. Those same conditions caused a rise in the number of timber, reinforced concrete and simple steel bridges located on Montana's road system.[23]

The Homestead Boom

In response to intense lobbying by the railroads and other special interest groups, the Federal Government enacted the Enlarged Homestead Act in 1909. Under the terms of the act, Congress allotted 320-acres to every homesteader willing to relocate to Arizona, Colorado, Nevada, Oregon, Washington, Montana or Wyoming. Through the efforts of dry land advocate Hardy Webster Campbell of South Dakota and railroad magnate James J. Hill, the Act drew over 500,000 homesteaders to Montana between 1910 and 1918. Because of the population incursion and the boom agricultural economy, promoters throughout Montana engineered the formation of twenty-eight new counties in the state before the boom ended in 1918.[24]

The counties initiated an ambitious program of road and bridge construction to provide the homesteaders access to the railroad terminals. The bridge construction industry went virtually unregulated in Montana until 1913. In many areas, simple timber bridges sufficed to provide crossings for local residents. The enlarged tax bases of the counties, however, allowed for the construction of over 100 steel truss bridges before 1917.

The Homestead boom in Montana provided a bonanza to the bridge companies. Each new county government sought to provide good transportation systems for their new constituents. The result was the construction of many bridges in the state by the counties before 1913--78 of which still survive. While simple timber and steel stringer bridges usually sufficed, the presence of a steel truss structure was the sign of a prosperous district.

Bridges constructed during the Homestead Boom reflect the evolution of bridge engineering technology. In the late 19th century, the companies constructed many combination wood and iron pin-connected truss bridges. But as manufacturing and

construction methods improved, the bridge companies constructed more riveted truss bridges. Most of these changes were brought about because of the requirements of the automobile and the need for reliable long and short-span bridges. Because of the large tax base and inflated agricultural prices, the counties were able to finance the construction of many of these bridges before the country's entry into the European War. What is more important, the structures are representative of the economics of bridge fabrication, transportation and construction techniques. Today, most which survive are located on secondary or off-system roadways and are testimony to the agricultural settlement of Montana.[25]

The Montana Highway Commission

The boom in agriculture caused Montana's population to increase dramatically between 1907 and 1917. The larger population--particularly in rural eastern Montana--caused the counties to go into debt for the construction and maintenance of new roads and bridges. At approximately the same time, the federal government was nearing completion of a federal aid package to assist the states in their road building efforts. The legislation required that funds be administered by a state highway commission. It was also likely, moreover, that state governments needed a method to regulate the activities of the bridge companies and the Good Roads organizations.[26]

In 1913 the Legislature created the Montana Highway Commission to provide assistance to the counties and thus enable the state to qualify for federal funds. The Commission, however, was authorized only to "give ... advice, assistance and supervision with regard to road improvement and maintenance throughout the state." The counties remained financially responsible for road and bridge construction, while the Commission provided the necessary designs and engineering expertise. The county commissioners continued to award contracts to the construction companies.[27]

The Montana legislature was hesitant to assume much responsibility or authority for the construction and maintenance of public roads and bridges in the state. There were virtually no funds available for the actual construction of any roads or bridges (there was funds available for demonstration projects). Anticipating the passage of the first federal-aid road act in 1916, the Commission requested that the counties prepare maps that showed all roads and bridges located within their boundaries. From these maps, the Commission established the primary road system in Montana. For the most part, the 1913/1914 maps reflect the system of roads which had evolved during the settlement boom and which form the basis of today's road network.[28]

The Legislature created the Commission to administer and advise the counties in their road and bridge construction endeavors. Before 1915, there is little mention of bridge construction or maintenance in the existing Commission records. This may indicate that the Commission still intended that the county commissioners rely on the proficiency of the bridge companies for the construction of new bridges in the state.[29]

The Bridge Department

In 1915, the legislature authorized the Montana Highway Commission to create a bridge department. Headed by bridge engineer Charles A. Kyle, the Department provided standard plans and specifications for all bridges in the state when construction costs exceeded $500 (by 1917, they had also developed plans for bridges that cost less than $500). After investigating several midwestern bridge departments, the Commission patterned the Montana division after the Iowa Commission's organization. Indeed, even the original standard bridge designs are similar to those developed by the Iowa Highway Commission. Bridge engineer Milo Ketchum described timber and reinforced concrete structures that are strikingly similar to those constructed in Montana. The method by which the bridge department awarded contracts and supervised the construction also appear to be derived from Iowa Highway Commission.[30]

The Bell Street Bridge at Glendive about 1924. (Montana Historical Society).

The Bridge Department distributed copies of the bridge designs and fifty copies of the bid sheets to each County Clerk's office. Although the bridge designs were housed at the county courthouses, the Commission required the contractors to request final plans from the Bridge Department in Helena. In this way, the department was able to maintain control over the construction process and ensure a

uniformity and consistency of design in every county. Although the counties were responsible for letting the contracts and paying for the structures, the Bridge Department supervised construction of the bridges and inspected them before they authorized payment to the contractors. The law, however, allowed the counties the option to ignore the service and build any type of bridge it wanted--regardless of the implications. Most counties, however, took advantage of the service provided by the Commission's Bridge Department.[31]

The Department completed their standardization of timber and truss bridge designs by 1917. Changes in vehicular requirements, however, contributed to the almost constant revision of the Department's standards. For all structures greater than 40-feet, the Department specified the construction of a standard steel truss--usually riveted Warren or Pratt trusses. For crossings up to 120 feet in length, the Department designated the use of pony truss bridges, while through truss bridges were common to crossings greater than 120 feet.[32]

Although foundations, abutments and piers were different in each case, the Department specified the use of tubular iron or steel piers filled with concrete--unless scour warranted the construction of concrete piers. Concrete piers and abutments were common to Montana bridges by 1922 as were timber approach spans. All of the bridges devised by the Department were designed for a life expectancy of 30-40 years (some are still in service after nearly 80 years).[33]

Between 1917 and 1918, the Bridge Department supervised the construction of 38 structures (seven of the bridges are still in use on Montana's off-system roadways). The bridges cost the counties a total of $225,000. This was the first large-scale construction program supervised by the Bridge Department after its creation in 1915. Bridge companies were employed by the counties to build the structures. The Commission's first annual report in 1916 noted that

> "Contract prices . . . for bridges built according to the requirements of Highway Commission standards have been no greater, and in many cases less, than those previously paid for structures of similar length . . . . [T]he structures built under Highway Commission standards are very much heavier than those heretofore erected."[34]

Unlike the pre-1915 system, the Department's standard designs allowed close estimates of construction costs that resulted in the faster delivery and erection of the bridges. The 1916 report stated that the new system stimulated positive competition between the companies that resulted in the counties receiving a quality product.[35]

The Federal Aid Road Act of 1916

In 1916, the United States Congress enacted the first Federal Highway Act. Administered by the US Department of Agriculture's Bureau of Public Roads, the legislation appropriated $75 million for a five-year program of road construction and improvement throughout the country. In Montana, however, the Act functioned more for design and planning purposes than for any actual construction. The Commission used Montana's $1,500,000 share of the funds primarily for road and bridge design. Since the Act stipulated that the states provide matching funds, the Montana legislature raised the vehicle registration tax in 1917. The actual

construction of roads and bridges was funded by county bond issues until 1922.[36]

There are 92 county-funded bridges remaining on the state's secondary and off-system roadways built between 1915 and 1922. There are forty-five steel truss structures, nine untreated timber, 25 steel girder and 13 reinforced concrete bridges. Consistent with Commission Bridge Department standards, all bridges less than 40-feet in length were timber, girder and reinforced concrete structures, while the longer spans were primarily steel Pratt and Warren truss bridges.

The 1920s

By 1921, severe drought and post-war economic depression had a profound, but surprising, impact on bridge construction in Montana. Although the tax bases of the eastern counties dwindled as the population declined and the economy weakened (60,000 people left the region during the 1920s), the Bridge Department's construction program remained centered in the eastern two-thirds of the state. The counties and the Montana Highway Commission constructed 184 bridges between 1923 and the onset of the Great Depression in 1930. Unlike the previous decade of economic prosperity, the Commission built only 37 steel truss bridges. To minimize costs, the Commission increasingly relied on timber, steel girder and reinforced concrete bridges rather than the more expensive through truss bridges. During the late 1920s, the Commission built nearly 100 timber bridges. There was also a rise in the number of steel stringer, girder and reinforced concrete bridges built by the Commission. Since the federal government emphasized the importance of farm-to-market or "feeder" roads in the 1922 road bill, the preponderance of bridge construction occurred in the remote rural areas of the state.[37]

In 1926, Federal Government made the Commission's Bridge Department responsible for the construction and maintenance of all bridges in Montana. The Montana legislature raised gasoline and vehicle registration taxes and mandated that the counties enact road levies to help pay for the massive road expansion program. After 1928, the Montana Highway Commission had full responsibility for letting construction contracts. Rather than contract each bridge out individually, the Commission let contracts for groups of bridges each year. Contracts to the fabricators were also let in groups on an annual basis. The Commission usually let contracts for bridge construction in specific counties in conjunction with road construction projects.[38]

Bridge Design and Construction

By the late 1920s, the Commission Bridge Engineer developed a method of bridge design that was similar to those in other western states. The engineer also borrowed bridge construction techniques from other states (notably Iowa) and adapted them for use in Montana. The engineer organized the design section of the Bridge Department into six units of six men each--each unit responsible for bridge design and construction in two of the twelve construction districts in the state. Each unit consisted of two engineers and four detailers/draftsmen. The chief engineer of the Design Section conducted the "plan-in-hand" inspection at the bridge sites before the Commission awarded the contract. The Commission employed field supervisors to oversee the work of the contractors on the bridges. The foreman oversaw all aspects of the bridge's construction and inspected the structure before the Commission

approved payment to the contractor. Often, as in the case of Evarts Blakeslee of Great Falls, the foreman used the experience gained during his employment by the Montana Highway Commission to form his own bridge construction company.[39]

Bridge fabrication and timber treatment plants were located throughout the United States. The steel manufacturers provided components for the truss, girder and reinforced concrete bridges. There were three Montana-based steel companies active in the state from the late 1920s until approximately 1956: Western Iron in Butte, the Foundry Department of the Anaconda Copper Mining Company in Anaconda and William Roscoe in Billings. In addition, thirty-four out-of-state fabricators supplied steel and treated timber to Montana contractors during the same period. The timber-treating plants were located in Oregon and Washington, while the steel fabricators were headquartered in Minnesota, Illinois, Colorado, Washington and Pennsylvania. These companies included the Minnesota Steel and Machinery Company, Bethlehem Steel, the Colorado Fuel and Iron Company and the Pacific Coast Steel Corporation. All steel companies maintained field offices in the major Montana cities. Cement, on the other hand, was provided by Montana manufacturers such as the Three Forks Portland Cement Company in Trident.[40]

While the fabricating companies were based on the West Coast and Midwest, bridge construction was dominated by Montana contractors after 1925. The companies were based in communities throughout the state, but most were located in Billings, Great Falls, Butte, Miles City and Helena. The most prolific bridge-builders in the state were Walter Mackin and William P. Roscoe of Billings.[41]

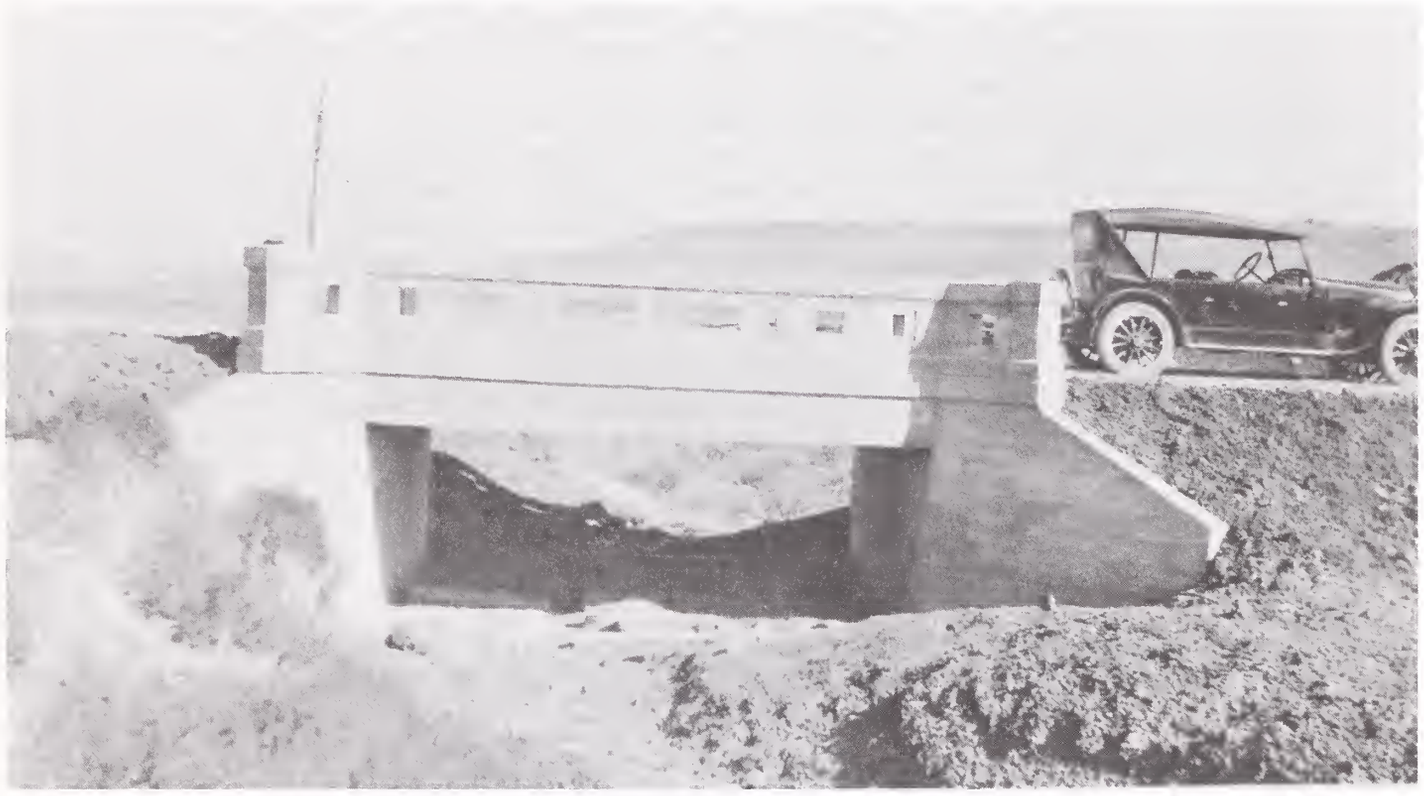
The Walter Mackin company was established about 1935. Between 1936 and 1945, the company constructed at least 71 timber, girder and reinforced concrete bridges throughout Montana. By 1949, the company was listed as Mackin & Son in the Billings city directory and was still in operation in 1991.[42]

The Hewett Bridge Company employed William P. Roscoe as a laborer in 1905. Roscoe went to work for William Hewett's Security Bridge Company in 1910 as a construction foreman and agent. By 1915, he was vice-president of the company. When the Security Bridge Company ceased operations in Montana in 1925, Roscoe went into business for himself as a bridge contractor. The company constructed at least 68 timber, reinforced concrete and steel girder bridges in Montana between 1930 and 1956 when Roscoe died. Its successor firm, however, the Roscoe Steel & Culvert Company was still in operation in 1991.[43]

The Great Depression

The Great Depression struck Montana in 1930. Drought and low agricultural prices forced 28 of the state's 56 counties to seek disaster relief by 1933. In an attempt to provide jobs to the army of unemployed in the state, the Legislature authorized the appropriation of a $6 million debenture to continue road construction in Montana. The state raised the funds by increasing the gasoline tax. In 1930, the US Congress enacted the Oddie-Colton Bill which gave the federal government full responsibility for the construction of roads through public-owned lands, Indian reservations, and federal reserves other than the national forests. Because approximately 13% of Montana included federal lands and reservations, the state was eligible for a large portion of the $80 million appropriation. Most importantly, the bill did not require

the state's to provide matching funds before they qualified for federal aid. The Oddie-Colton Bill in 1930 and the 1931 Montana debenture funded the state's road and bridge construction program until 1933.[44]



Montana Highway Commission reinforced concrete slab bridge, circa 1930.

The downturn in Montana's economy was reflected in the Montana Highway Commission's timber bridge construction program. The Commission built 51 new timber bridges in 1931. A year later, however, the Commission was able to finance the construction of only 27 timber bridges. Timber bridges accounted for 55% of the spans built by the Commission between 1931 and 1933. The Commission built only 22 steel truss and 36 steel stringer bridges. During that period, however, the Commission constructed 56 reinforced concrete bridges--the most intensive building program for this type of bridge until the 1960s. The election of Franklin Roosevelt in 1932 and the beginning of his economic relief programs in 1933 sparked a substantial increase in bridge construction by 1934.

The effect of Roosevelt's programs on Montana and the Montana Highway Commission persisted to 1941. The economic revolution instigated by the President resulted in a road and bridge construction program unparalleled in the state's history until the 1960s and 1970s. The greater demands placed on the Commission's Bridge Department by the influx of New Deal dollars, initiated a revision of bridge standards and construction requirements. To accommodate the rapid expansion and improvement of the road system, the Commission and the Bureau of Public Roads constructed large numbers of simple timber, steel girder and reinforced concrete

structures. Simple to construct these bridge types were far cheaper than the old truss bridges. Timber bridges were the bridge type of choice for the New Deal Years.

In late 1933, Roosevelt initiated the National Industrial Recovery Act. The law appropriated $400 million for the construction of roads and bridges without requiring the usual state matching funds (regular federal-aid funding was not restored until 1936/1937). In addition to projects on the federal-aid highway system, the funds were also used to construct and maintain secondary and feeder roads in the isolated agricultural areas of Montana. National Industrial Recovery Act regulations stipulated that the Commission give preference to hiring in-state contracting companies to build bridges with the use of local labor. The Act required that construction activity rely heavily on the use of manual labor rather than machinery for construction purposes. The United States Supreme Court determined portions of the Act unconstitutional in 1934. Many of the regulations specified by the Act, however, were adopted by the Project Works Administration (PWA) and the Works Progress Administration (WPA).[45]

Although the National Industrial Recovery Act stimulated road and bridge construction in Montana, the state slowly regained the momentum it possessed in the 1910s and 1920s. A new torrent of federal funding in 1935, however, resulted in an intensive bridge construction program in Montana and the expansion of the Commission's Bridge Department. In 1934, the Commission funded the construction of 78 bridges. Timber bridges accounted for 66% of the 110 bridges built by the Commission in 1935. Backed by WPA funds and manpower, the Montana Highway Commission built a record number of bridges in 1936. From 1936 to 1941, out-of-state and in-state contractors constructed at least 636 steel truss, timber, girder and reinforced concrete bridges.

The Commission expanded the Bridge Department to compensate for its augmented responsibilities in 1935. Because of the shortage of qualified bridge engineers and a decline in the copper industry, the Bridge Department hired mining engineers from the Anaconda Copper Mining Company. Because they were adept at the design of tunnel supports, trestles and head frames, the mine engineers were well-qualified to design steel truss and timber bridges. Bridge Department chief Benedict J. Ornburn expected each of the six design sections to design one major bridge and four or five minor structures per month. In addition, Ornburn placed bridge design engineer John Morrison in charge of the preconstruction activities while Russell A. Stephenson supervised the construction section. The Division Engineer usually determined the bridge location.[46]

New Bureau of Public Roads standards stated that "Bridge alignment should conform to the overall alignment of the roadway." Previously, the Commission located bridges for minimum cost reasons and paid little attention to the approach road curvature. Before the 1930s, bridges were built at right angles to the channel and the road approaches built to accommodate the structure. By the late 1930s, the number of skew bridges constructed by the Department and located on the primary road system increased. Skew bridges are structures built at an oblique angle to the river or stream channel Bridges suitable for skew sitings included timber, reinforced concrete and steel stringer structures.[47]

Nearly all bridge-building activity occurred in the rural eastern counties and in the

Butte-Anaconda area. By 1937, the federal government reinstated the old federal-aid program and special New Deal funding was gradually withdrawn by the US government. In Montana, however, road construction activities continued to increase even though it decreased in other parts of the country. Between 1937 and the American declaration of war against the Axis powers in 1941, the Commission built 537 bridges, including 22 steel truss structures and 455 timber bridges.

In 1937, Congress allocated funds directly to the relief and work agencies of the federal government. Unlike earlier appropriations, however, the funds were administered directly by the federal agencies rather than to the New Deal programs. Consequently, while make-work programs in the state declined during the late 1930s, projects funded directly by federal agencies remained active. The regular federal-aid process in effect before 1930 was reinstated in 1936 and road and bridge construction continued. From 1937 until January, 1942, the number of bridges constructed by the Commission steadily grew, reaching its peak in 1940 with the construction of 149 bridges. Thereafter, the number of new bridges built by the Commission steadily dropped as the demands of the country's war effort took precedence over the necessity for new roads and bridges.[48]

Civilian Conservation Corps crew constructing the Fishtail Bridge in northwestern Montana, 1934. (Vurl Springer).

World War II and post-War New Directions

After 1941, Montana's road program nearly ceased with only maintenance and a few construction projects occurring on the state's highway system. The Federal-

Aid Road Act of 1941 placed considerable emphasis on the nation's military effort. The federal government required no matching funds for projects vital to national defense. To accommodate heavier truck traffic, the Bureau of Public Roads modified load limits on roads and bridges to conform to the increased demands placed on the nation's transportation system. The following year, however, the government nearly froze all transportation expenditures.[49]

The Mouat Mountain View Mine in Stillwater County was one of three operations extracting chromite in the Beartooth Mountains during World War II. Much of the Highway Commission's bridge-building activities was devoted to improving the roads connecting these strategic mines with U. S. Highway 10 (Montana Historical Society).

Rationing of gasoline, tires and automobile parts by the federal government contributed to a drastic reduction in wartime highway travel. This resulted in a decrease in the amount of gasoline and oil sales and, consequently, a loss of tax revenues for the Commission. Since the Commission relied on tax revenues to provide matching funds for federal funding and to finance minor maintenance projects, virtually no highway work occurred in the state until 1944. The Federal government allowed only maintaintence work on strategically important roads and bridges (i.e. the roads connecting Anaconda, Butte and Walkerville, U.S. Highway 91 between Butte and Great Falls and Montana Highway 78 in Stillwater County).

The Commission kept the remaining roads and bridges in only "tolerable" condition. To accommodate a significantly smaller budget and staff, the Commission reduced the size of the Bridge Department to better manage the new circumstances.[50]

Between 1942 and the enactment of the Federal-Aid Road Act of 1944, the Commission constructed only 48 new bridges. Approximately 75 percent of them were timber bridges located in the western one-third of the state. In addition, the Commission constructed several steel stringer and reinforced concrete bridges in Stillwater County for strategic purposes. German U-boat depredations in the Atlantic Ocean, severed the nation's supply of chromium ore. The largest source of the mineral in the United States is located in the Beartooth Mountains near Nye. Consequently, the up-grade and maintenance of bridges between the mines and mills and U. S. Highway 10 was important to the Allied war effort.[51]

By mid-1944, the successful conclusion of the war was imminent and the federal government planned for post-war road and bridge construction. Unlike the construction program of the 1930s, however, the Federal government emphasized the establishment of a system of highways important to national defense--the germ of the interstate highway system of the late 1950s. The 1944 Road Act also established the state's secondary highway system. The system was based on the farm-to-market and feeder roads of the 1920s and 1930s. The Commission required minimal standards for the roads because of wartime restrictions placed on construction and maintenance. The Act also stipulated new criteria for bridges located on the secondary highway system.[52]

Before 1944, the Commission based bridge designs on local needs and site locations. After 1944, however, the Bureau of Public Roads and Bridge Department based their bridge designs almost solely on traffic volume. In sparsely populated areas, therefore, simple steel stringer bridges could usually provide adequate service to the area. The Act also specified only minimal improvements to the 358 steel stringer and timber bridges built in remote areas in the 1920s and 1930s. It stipulated that "the roadway width of an existing bridge must be as wide or wider than paved width of adjacent road improvements." In Montana, however, this provision of the Act was never fully enacted since many pre-1945 bridges are still narrower than the approach roadways. Indeed, in 1956, the Automotive Safety Foundation found that 94% of the bridges located on the state's secondary and primary systems had roadway widths narrower than the appropriate design standard. Further, the report stated that "On 408 of these bridges the roadway widths are below tolerable minimums . . . ." Narrow bridges were (and are) a hazard to drivers long after the Highway Commission adopted the new standards.[53]

The end of World War II heralded the beginning of a new era of road and bridge construction that continued until the late 1980s. The new construction program was rooted in the deficiencies of previous road building efforts, economic prosperity and the arrival of the "Golden Age" of the Automobile. Highway expansion in the early 1950s culminated in the construction of the Interstate Highway System in 1956. The decade also saw the continuing decline in the number of new steel truss bridges constructed by the Commission.[54]

The 1950s

Shortly after the end of World War II, the Montana Highway Commission formed a committee to study the problems that faced the state's highway system. The Montana State Highway Planning Survey noted that much of the construction done on the state's transportation system was completed before 1941 and that most roadways were already obsolete because of increased traffic volume, faster automobile speeds and increased vehicle weights. The committee concluded that the system was "tolerable" under existing conditions, but up-grading was necessary. In response to the committee's recommendations, the Montana Highway Commission embarked on an ambitious construction program. Between 1948 and the initiation of the interstate program in 1956, the Commission constructed 471 bridges. Again, 60% were timber bridges, but the number of steel girder and reinforced concrete bridges had risen simultaneously. Because of the cost of through truss bridges and the refinement of girders, the Commission no longer preferred truss bridges as the principal conveyor of traffic over large barriers.[55]

The original Browne's Bridge over the Big Hole River. It was the last operating toll bridge in Montana. The King Post trusses and rock crib piers were typical of early bridge structures in the state (Montana Historical Society).

In 1953, the American Association of State Highway Transportation Officials (AASHTO) published a new set of bridge standards in anticipation of the interstate highway program. Although specific in load ratings and width, the standards permitted local highway departments to modify them to meet local needs. This included unusual types of structures and bridges over 400-feet in length. In few cases, however, did the Bridge Department deviate from the standards developed by AASHTO.[56]

Because of revenue shortfalls in the eastern Montana counties, the Montana Legislature sought alternate means to funding bridge construction projects in 1953. In a method reminiscent of the way the territorial assemblies solved the same type of problem, the Legislature created a toll bridge authority with the power to "sell bonds and to take other action necessary to construct, maintain and operate toll bridges." Composed of members of the Montana Highway Commission, the committee was created specifically to provide a toll bridge on the Missouri River between Lewistown and Malta on U.S. Highway 191. Perhaps anticipating the construction of other toll bridges, the Legislature stipulated that no toll bridge could be located within fifty miles of an existing free bridge, unless 20% of the tax-paying citizens in the county wished otherwise. Only one bridge in Montana was initially planned as a toll facility under this program--the Fred Robinson Bridge over the Missouri River.[57]

In 1955, The Legislature authorized the Montana Highway Commission to allocate funds for the construction of bridges that could not be financed under the regular provisions of the federal-aid road acts. This included bridges located on the primary, secondary and county roads in the sparsely populated eastern counties of the state. In 1948, the Montana State Highway Planning Survey noted that while highway use patterns had changed significantly since 1929, there had been no change in the basic tax structures of the state or counties. The committee wrote,

> The county road problem is much like the county school problem in that smaller counties with low population, low assessed valuation, large areas of tax exempt lands, etc., are unable to raise sufficient revenue to meet their road needs even though they levy the maximum amount year after year.

The Legislature authorized the Commission to allocate up to $1 million per year for the construction of bridges on the primary system. The money was segregated from the regular highway construction funds and was repaid by the counties over a five-year period. This method of funding bridge construction did not require the counties to have money in hand before federal matching funds were allocated to them.[58]

Just prior to the initiation of the Interstate Highway Program, the Commission expanded the primary and secondary road system in 1956. In addition, the Automotive Safety Foundation found that 96% of the state's highway bridges did not meet federal standards for load carrying capacity. The Foundation did not believe this was a serious deficiency, but noted that nearly all the bridges built since the end of World War II did not meet the standards stipulated by the federal government. On 192 bridges (about 1%), moreover, the Foundation discovered that the rated load-carrying capacity was "less than the tolerable conditions established for minimum traffic service." The following year, the Legislature initiated a ten year program to finance costly bridges on the secondary system.[59]

By 1946, the Commission ceased construction of steel truss through bridges and, instead, relied on girder and timber bridges to carry traffic across barriers. Demands on the highway system created by modern vehicles, particularly heavy trucks, necessitated new materials and designs to accommodate the greater traffic. The Commission, consequently, sought new techniques for bridge construction that were not overly expensive. Prestressed concrete was ideally suited to the construction program initiated by the Commission after 1956. The uniformly streamlined structures easily accommodate the greater demands placed on them by late 20th

century traffic requirements. While timber and steel truss bridges predominated on the state's roadways before the Second World War, prestressed concrete and steel girder bridges have dominated the landscape since then.[60]

The different structural and material types that illustrate the evolution of bridge design in the 19th and 20th century are represented on Montana's transportation system. Developed by the Commission for specific purposes, they were, for the most part, well suited to the demands placed on them by their users. What follows are sections describing in detail the various bridge types located on Montana's roadways with examples of structures that are representative of the type. Following the report are lists of bridge types (i.e. timber, truss, girder and reinforced concrete) that are on or eligible for listing on the National Register of Historic Places.

PART 2 - TIMBER BRIDGES

Timber bridges are ubiquitous to the Montana landscape and integral to the history of Montana and the Montana Highway Commission. Unlike many other states, which relied on reinforced concrete bridges to expeditiously span obstacles, the Montana Highway Commission constructed hundreds of timber bridges to economically and efficiently cross barriers in the 1920s and 1930s. The Commission envisioned timber bridges as a temporary solution to crossing the myriad creeks and coulees in the state. However, most of the timber bridges constructed by the Commission between 1931 and 1956 are still in service on Montana's primary and secondary road systems.[1]

The simplicity of design and durability of timber bridges is representative of the Commission's early efforts to modernize the state's fledgling highway system. Over 940 timber bridges are still in use on Montana's primary and secondary roadways--a visible reminder of the history and development of 20th century transportation programs in Montana.

Built in 1915, the Bluewater Creek Bridge in Carbon County is representative of timber bridges constructed in Montana just after the creation of the Montana Highway Commission. The superstructure and portions of the substructure are composed of untreated timber. The metal guardrails replaced the original wood rails in the late 1980s.

Structural Specifications

Timber bridges are simple structures that consist of a wood deck supported by timber stringers with wood guardrails. On larger streams and gullies, the bridges often include multiple spans supported by timber pile bents set in the stream or coulee beds. Timber bridge spans average between 19 and 25 feet in length. Before 1915, the typical bridge span length was 15 feet. Based on railroad standards, the shorter spans proved unnecessary for lighter vehicular traffic.

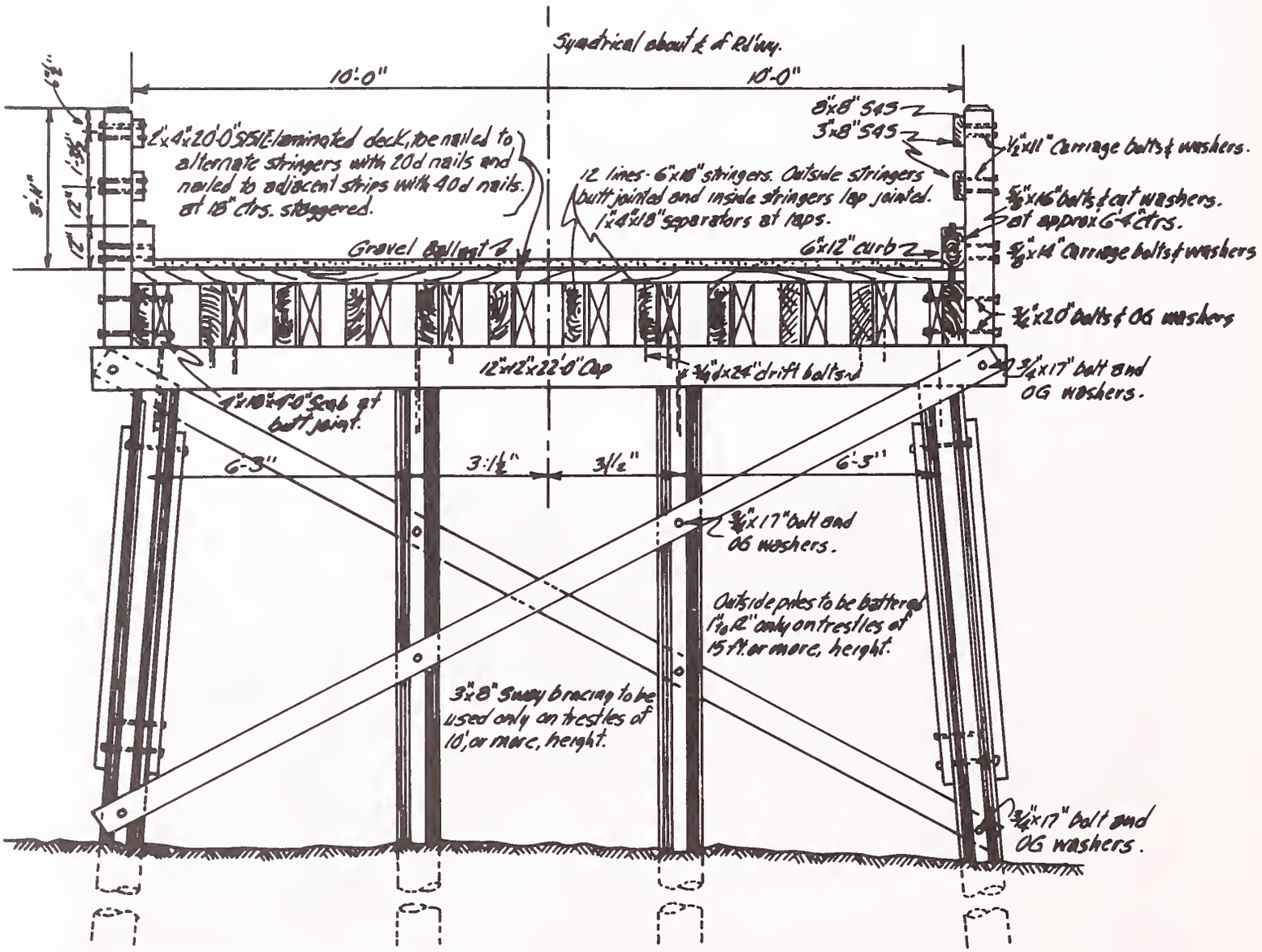


Diagram of a typical Montana Highway Commission timber bridge (E. L. Predmore).

Timber bridges are generally twenty-four feet wide with 2 two-rail wood guardrails flanking the bridge deck. The pile bents are generally set directly in the stream or coulee bed unless site conditions (i.e. too much gravel or clay) warrant concrete

footings. If the bridge is a particularly long structure, then the bents are supported with sway braces and cross beams. The abutments for this type of bridge usually consists of earth supported by wood backwalls and pilings. Occasionally, however, a the abutments may be supported by log cribs or reinforced concrete walls.

The stringers are horizontal wood beams that connect the abutments and form the superstructure of the bridge. Before 1930, the stringers consisted of 12 lines of 4" x 16" timber beams. After 1930, the stringers consisted of 6" x 18" or 8 x 18" timbers. In northwestern Montana, however, maintenance crews often used log stringers. Bridge decks were constructed of laminated wood two-by-fours with a gravel or plant mix (gravel and asphalt) overlay. The Commission designed the bridges to support a moving 15-ton vehicle with two-thirds of its weight resting on the rear axle (an H-15 loading).[2]

History

The Montana Highway Commission developed a simple timber bridge design in 1915. By the mid-1920s, however, the introduction of treated timber bridge components and heavier vehicle weights compelled the Commission's engineers to modify the design. Creosote-treated timbers proved to be the most important modification to the design because it increased the durability and longevity of the structures. Only 17 untreated timber bridges designed by the Commission remain in use on the Montana's primary and secondary system in 1986.[3]

The Montana Highway Commission's Bridge Department initially was not empowered to finance the construction of any bridges in the state. Instead, the department developed plans and specifications for timber, steel girder and truss bridges that would be constructed on the newly designated primary and secondary road system. If a bridge cost less than $500, however, the counties were not required to seek the assistance of the Bridge Department. Although many timber bridges did not meet the $500 requirement, the Bridge Department, nevertheless, had developed a set of plans detailing their specifications by 1917. Evidence suggests, moreover, that the bridge department adopted timber bridge plans developed by the Iowa State Highway Department in about 1909.[4]

By 1921, severe drought and post-war economic depression had a profound, but surprising, impact on timber bridge construction in Montana. Although the tax bases of the eastern counties dwindled as the population declined and the economy weakened, the department's timber bridge construction program flourished in the eastern two-thirds of the state. Between 1920 and 1930, 32 timber bridges were constructed in Montana--60% of them located in the eastern counties. The preponderance of timber bridge construction occurred in Custer, Dawson, Valley, Roosevelt, Prairie and Blaine counties.[5]

Nine fabricating plants provided timber bridge components to Montana contractors--five companies were located in Washington and four in Oregon. Since the semi-arid climate of Montana affected the strength of the state's supply of Douglas Fir, Montana bridge engineers relied on the greater tensile and compressive strength of Douglas Fir trees harvested in the wetter climate of the Pacific Northwest. The shops manufactured bridge components to Commission specifications. They were then treated with creosote and the components shipped to the building sites.

Seattle's West Coast Preserving Company and the Forest Product Treating Company of The Dalles, Oregon were the most active timber suppliers to Montana bridge builders. The West Coast Wood Preserving Company provided materials for at least 94 bridges in the state between 1930 and 1939.[6]

Although out-of-state fabricators supplied the components, in-state contractors dominated the actual construction of timber bridges. Of the 47 bridge contractors operating in Montana between 1930 and 1940, 70% were based in the state--mostly in Great Falls and Billings. Of those contractors, Walter Mackin of Billings was the most prolific--building at least 62 bridges between 1936 and 1940. W. P. Roscoe of Billings, and D. M. Manning of Hysham were also active in the state during the 1930s. There is some indication that bridge builders sometimes sub-contracted projects to other companies.[7]

A standard timber bridge during construction in 1929. The bridge was located in the vicinity of Miles City and was built by Frank Robbins for the Montana Highway Commission (photograph courtesy of Bob Robbins).

Thirteen out-of-state contractors worked in Montana during the 1930s. While most of the companies were based in North Dakota and Minnesota, firms from Idaho, South Dakota and Missouri also operated in Montana. Not limited to projects near the state's borders, these companies constructed bridges throughout Montana. The Massman Construction Company of Kansas City, Missouri, and the North Dakota-based Bismarck Construction Company were the most active out-of-state contractors in Montana.[8]

During the Great Depression in the 1930s, the Commission's timber bridge program symbolized the downturn in the state's economy. Although the Commission constructed a significant number of reinforced concrete bridges in 1931 (26), only 51 new timber bridges were built that year. A year later, however, the Commission

financed the construction of only 27 timber bridges. Government funds sparked renewed road construction programs in Montana in 1933. Consequnetly, there was a substantial rise in the number of timber bridges constructed by the Commission--63 structures located primarily in eastern Montana.

In 1933, the National Industrial Recovery Act provided money to Montana for road construction without requiring the routine matching funds. The Highway Commission used the money to improve and maintain the myriad farm-to-market and feeder roads in the isolated farming and ranching areas of the state. The Act's regulations stipulated that the Commission give preference to hiring in-state construction companies. The legislation also required that construction activity rely primarily on the use of manual labor obtained in the area in which the construction would occur. Many of the regulations specified by the Act were adopted by the WPA in 1935.[9]

During the Thirties, the Montana Highway Commission sought the swift bridging of the state's roadways. The Commission originally intended timber bridges as temporary structures (much like the first timber railroad bridges) that would eventually be replaced by reinforced concrete or steel stringer bridges. The Commission often built timber bridges (particulary in eastern Montana) because of the lack of a readily available source of aggregate in the vicinity of the proposed bridge site.

Since the bridge components were prefabricated for specific sites, they could be easily assembled by relatively unskilled labor. Many workers recruited by the Civilian Conservation Corps and the WPA had no experience building bridges. They could not, therefore, be used for complicated steel truss construction or for reinforced concrete bridges. Timber bridges required aprroximately one month to construct with unskilled labor (a little faster if the crew was experienced). Timber bridges were ideally suited to the make-work programs of the New Deal years since it emphasized economy of materials and the maximum use of labor.

The National Industrial Recovery Act stimulated road and bridge construction in Montana. Montana bridge contractors constructed 56 timber bridges in 1934 and 73 timber structures in 1935. Backed with WPA funds, the Montana Highway Commission's timber bridge program boomed beginning in 1936. Out-of-state and In-state contractors built 451 timber bridges between 1936 and 1940.

Nearly all bridge building activity occurred in the rural eastern counties hardest hit by drought and depression. The lion's share of the timber bridge construction was concentrated in the seven counties adjoining the massive Fort Peck Dam project. WPA construction crews built 150 timber bridges in the counties surrounding the dam project--34 were located in McCone County alone. The busiest years for timber bridge construction in Montana occurred in 1936, 1939 and 1940. The New Deal lost considerable impetus by 1938 as Roosevelt's economic programs regenerated the nation's economy. The number of timber bridge projects let to contract by the Commission, however, continued to increase until 1940, when builders constructed 110 timber bridges.[10]

After the U.S. entry into World War II, Montana's road construction program nearly ceased. Only maintenance and a few building projects occurred on the state's

highway system until the end of the war in 1945. Although the Commission built 31 new bridges in 1942, they built three in 1943 and only two in 1944. In the aftermath of the war, however, the Commission again resumed its road and bridge construction agenda.[11]

The Montana Highway Department built 381 timber bridges between 1946 and 1956. Construction again was concentrated in eastern Montana, with the Forest Service upgrading the bridges located in the western forests. Although the level of intensity never equaled that of the New Deal years, the post-war timber bridge program was just as extensive. The highway department began replacing many timber bridges with prestressed concrete bridges and steel and concrete culverts. During the 1930s, steel culvert technology had not developed sufficiently for their use as crossings. Consequently, the Commission built timber bridges as an alternative. Today, the process has reversed itself, and the bridges are slowly giving way to culverts.[12]

PART 3 - TRUSS BRIDGES

Until the introduction of steel girders and reinforced concrete in the first decade of the 20th century, truss and timber bridges dominated the transportation landscape in Montana. Simple timber bridges often represented economic boom times and periods of rapid highway expansion. The more sophisticated truss bridge, however, symbolized economic prosperity and social stability in in both rural and urban Montana. They were also the only structures capable of spanning the major river crossings in the late 19th and early 20th centuries. Nationally, this type of bridge epitomized the industrial development of the United States and marked the beginning of scientific bridge design, the rise of the civil engineer and the birth of modern bridge construction techniques.[1]

Truss bridges consist of a framework of wooden or metal members arranged in triangles to create a structure capable of spanning a crossing. The triangles provide rigidity to the structure and endure both the tension and compression forces of live and dead loads by transmitting them to the abutments through the steel (or iron) or timber structural members. There are two means of classifying types of trusses: by the relationship of the trusses to the roadway and by the configuration of members within the trusses themselves. In the former, there are two basic types of truss structures: the through truss and the deck truss. A deck truss bridge is supported by trusses located underneath the roadway. A through truss structure has the trusswork located above and alongside the roadway, thereby forcing the user to pass through the structural components of the bridge.

The modern timber and iron truss bridge was primarily a creation of American inventors. While European bridge-builders concentrated on masonry arch spans during the first six decades of the 19th century, the demands of the expanding railroad networks in the United States forced American engineers to experiment with a variety of different truss types. In 1859, engineers developed pin-connections for truss bridges. Pin-connections simplified the construction process and permitted the prefabrication of bridge components. The rapid expansion of the railroad system and the rise of the bridge companies depended directly on this development. American bridge engineers quickly embraced the new technology and pin-connections became standard to truss bridges throughout the country for the next half-century. After 1883, the railroads aided in the dissemination of truss bridges in Montana since they could easily transport the components to the vicinity of the construction site.[2]

While American engineers pioneered the development and use of the truss bridge, they were slow to adopt many of the innovations made by European bridge engineers in the late 19th century. Since pin-connections functioned as a hinge and did not transfer bending stresses, it was easier for American engineers to calculate the loads carried by each section of the truss. In Europe, however, pin-connections were not popular with bridge builders because they were not as concerned with economy or expediency of construction. Instead, they relied on riveted joints and heavy plate girders for the components of their truss spans. Because of technological limitations, engineers found it difficult to calculate the loadings when rivets were involved.[3]

Before the 1860s, bridge builders often drove heavily-laden wagons onto a completed bridge. If the bridge withstood the weight of the wagons, then it was opened for use. If not, the bridge was strengthened or rebuilt. Until engineers

understood the mathematics of live and dead loads on bridges, bridge failures were common. During the 1870s, approximately 40 bridges a year collapsed in the United States. Half of the bridges that failed were timber highway spans.[4]

With the introduction of pneumatic field riveting equipment about 1890, riveted Pratt and Warren truss bridges eventually became the dominant bridge type on the nation's railroads and eventually on the highway system. The use of riveted connections led to many advances in fabrication shop practice, including the temporary construction of the structure in the shop before it was moved to the construction site and the utilization of different types of rivets for specific structural purposes (detailing). In Montana, pin-connected truss bridges continued to be built by the bridge companies and the counties until about 1925. There are also many examples of pre-1925 riveted bridges in the state.[5]

Initially constructed of wood, truss technological improvements coincided with the refinement of metallurgical processes. By the late 1850s, iron became a common component to most types of truss bridges. Until 1860, most truss bridges were combination structures with the wood acting as the compression members while the iron functioned in a tension capacity. By the end of the Civil War, the railroads constructed wrought-iron bridges in great numbers. But by 1890, however, the steel industry had grown and improved sufficiently that,

> . . . the advantages of steel were undisputed. Its previous drawbacks having been remedied, any doubts as to its strength, reliability and versatility were removed and the engineering profession embraced it . . . . The age of iron had come to an end within a single generation.

With the introduction of steel, longer and more massive truss bridges were constructed to take advantage of the new material. The refinement of steel production and the rise of the bridge engineering profession, initiated the great age of steel truss bridge construction in the United States.[6]

The first truss bridges in the United States were simple timber structures designed purely for vehicular use. By the early 1830s, however, the development of the railroads spurred the improvement of the truss bridge. Prior to 1840, craftmen (usually carpenters) normally designed simple wood trusses to suit local needs. While acceptable for vehicular traffic, it was not suitable to the greater demands of the railroads. Trusses were well suited to lowgrade crossings (as were girder bridges in the next century). William Howe invented a truss that used timber for the chords and web diagonals (compression) and iron for the vertical members (tension). Patented in 1840, the Howe truss was the first scientifically designed truss and proved ideal for the needs of the railroads. The Howe truss incorporated many of the features important to the development of the truss bridge. Easily prefabricated by the factories, unskilled laborers often assembled the bridges. By 1850, the Howe truss was the standard railroad bridge in America.[7]

Thomas and Caleb Pratt developed a truss in 1842 and patented the design in 1844. One of the first scientifically designed trusses, the Pratt truss was somewhat similar in appearance to the Howe truss. That was, however, the only similarity between the two types. Instead, the Pratt truss used vertical compression members of wood and the iron diagonals as tension members. As a result, the shorter compression

members reduced the chance that the structure would buckle at a crucial moment. By 1850, the Pratt truss was composed of wood or metal or a combination of both components.[8]

The Pratt truss was not originally favored by the railroads because it required more iron for the diagonals and was, consequently, more expensive. Although initially more costly than the Howe truss, the Pratt truss required less maintenance, was more durable and was less prone to failure. By 1890, engineers had modified the truss until it was the standard all-steel truss bridge on both the railroads and highways. The majority of steel highway bridges constructed during the first twenty-five years of the 20th century were simple Pratt trusses.[9]

This wooden Howe truss bridge was located on the Clark's Fork of the Yellowstone River near Fromberg. Built in 1909, a reinforced concrete arch bridge replaced it in 1914 (Fromberg Service Club).

The bridge companies built great numbers of Parker and Pennsylvania truss bridges in the United States before World War I. Essentially variations of the Pratt truss bridges of the 19th century, the bridges were particularly suited to the railroads, high traffic roadways and exceptionally long span lengths. The most prominent bridge of this type is the Snowden Bridge in Richland County.

Although not as common as Pratt or Warren truss bridges, there were a significant number of Pennsylvania and Parker trusses in Montana. The Fort Keogh Bridge near Miles City in Custer County is one of the few pre-1915 Pennsylvania truss bridges remaining in use on Montana's roadways. Developed by Pennsylvania Railroad engineers in 1875, the truss was a modification of the Pratt truss. It

consisted of additional polygonal top chords to help support greater weights.[10]

The Fort Keogh Bridge was built by William S. Hewett and Company in 1902. It was one of ten bridges built on the Yellowstone River between 1902 and 1915. Nine of the bridges were Pennsylvania truss structures (this is the only one extant). Like many other Pennsylvania truss bridges in Montana, the Fort Keogh Bridge was built in combination with a Pratt truss (one of the three spans). The bridge accommodated the agricultural development of the area during the homestead boom. The United States Department of Agriculture rehabilitated the bridge in the 1970s.

The Fort Keogh Bridge. (HAER Photograph by Jet Lowe).

Captain James Warren and Theobald Monzani of England patented the Warren truss design in 1846. Although originally built with pin-connections, the Warren truss bridge was the first to have only riveted connections by 1915. The truss transferred loads through triangulation of its members with no verticals, the diagonals served in either tension or compression. The Warren truss is distinguished by the "W" configuration of the diagonals. Since the bridge was routinely riveted, the cost was prohibitive for its use as a highway structure until field riveting machines were made

available in the 1890s. In 1915, the Montana Highway Commission's Bridge Department specified that Warren trusses were more economical for spans reaching between 40 and 220-feet if a through truss was necessary.[11]

Steel truss bridges were complicated and required considerable effort to construct. A bridge site was chosen by either the Commission or the county commissioners. Core drilling established whether the underlying river or stream bed was suitable for the location of a large bridge and the type of foundations the structure would need. After the cofferdams were constructed and the pilings driven, the construction crews poured the concrete piers and abutments. The crews also constructed wooden bents upon which the steel superstructure of the bridge rested until it had been assembled and set into place.

Depending on the length of the spans, site conditions and the type of connections, the crew usually built the bridge directly on the piers and abutments. Occasionally, the structure was built on shore and winched into place. Once the construction crews completed the superstructure and the bridge was located on the piers, the deck was added, connections tightened, guardrails added, etc.

The forms supporting the structure were also slowly removed--allowing the bridge to settle into place. Sandbags or crib piers were the last to be removed by the builders. The contractors built the approach spans after the completion of the superstructure. They usually consisted of simple timber or steel stringer spans, but sometimes were reinforced concrete T-beam, slab or steel spans--depending on the size of the main structure and the abutments. This basic method of steel truss bridge construction changed little between the mid-19th century and the late 1940s.[12]

Core drilling rig for the Huntley Bridge on the Yellowstone River in 1944. (Photograph courtesy of Bob Robbins).

After World War II, the Commission embarked on a major road and bridge construction program in Montana. Between 1945 and 1956, the Bridge Department designed and constructed 574 timber, reinforced concrete and steel girder bridges in the state. Only 15 of the bridges, however, were truss structures. Eighty-six percent of the truss bridges located on secondary and off-system roads are simple one-span pony Warren structures (pony trusses are basically through trusses without the overhead members). The Billings-based W. P. Roscoe Company built the last through truss bridge in 1947. The bridge is located on Montana Secondary 402 in Powder River County near Broadus. The steel Pratt truss bridge crosses the Little Powder River and was fabricated by the American Bridge Company of Gary, Indiana. The multi-span bridge is 257-feet long and 20-feet wide and is supported by reinforced concrete abutments. Because it is located on a secondary road, the bridge has a wood deck.

The Little Powder River Bridge marked the culmination of through truss bridge construction in Montana. Because of the construction expense of the structures and their limited clearances and widths, the Montana Highway Commission turned increasingly to other, more efficient, bridge materials. Thereafter, the Commission relied almost exclusively on steel girders and reinforced and prestressed concrete for bridge structures located on Montana's highway system.

Deck Truss Bridges

Unlike the through truss structures, the primary supports for deck truss bridges are located underneath the roadway. They are, therefore, more rigid by design and more costly in materials. Many are continuous span structures with relatively complex mechanisms to compensate for load weights and thermal expansion. The railroads intially developed deck trusses since they offered no height limitations for locomotives and could accommodate greater weights. Because they are continuous, deck truss bridges are not divided into separate units (spans). The bridge, thus, functions as a unit. The load on one panel is systematically transmitted to the others, thereby distributing the load to the entire structure.[13]

In 1897, the King Bridge Company constructed the first deck truss bridge in Montana. The bridge crosses the Dearborn River in Lewis and Clark County and provided access for the farmers to the railroad center in Great Falls. The Dearborn River High Bridge is the only one of its kind in Montana. The structure is a half-deck pin-connected Pratt truss bridge. The deck is attached to the superstructure midway between the upper and lower chords. Like many deck truss bridges of the 20th century, this span was designed to span a deep canyon.[14]

While engineers favored continuous span bridges for railroad purposes after 1900, they were primarily limited to girder bridges. By World War I, however, improvements in steel manufacturing and engineering analysis caused an increase in highway deck truss bridge construction. Monolithic continuous deck truss bridges were constructed on the east coast and in Texas and California. Not surprising, however, the trend was slow to reach Montana. Although the Montana Highway Commission's Bridge Department formulated a standard deck truss design in the late 1910s, no bridge of that type was constructed in the state until 1920.[15]

The Dearborn River High Bridge (HAER photograph by Jet Lowe).

The Commission designed and built hundreds of timber, steel girder, through truss and reinforced concrete bridges, but built few deck truss structures. They erected only two deck truss bridges in Montana during the 1920s. Both were Pratt trusses designed to carry relatively light vehicular traffice across deep crossings. By the 1930s, however, the deck truss was adapted for use on crossings wider than standard for through truss bridges. Thus, they functioned in much the same capacity as the steel girder and floor beam bridges. Unfortunately, though, they were also more expensive and labor intensive, requiring special construction methods and more skilled workers.

The Gardiner Bridge was designed by the Bureau of Public Roads and was the last Pratt deck truss bridge built in Montana. Built by Stevens Brothers of St. Paul, Minnesota in 1930. The bridge spans the Yellowstone River at Gardiner and facilitated traffic into Yellowstone National Park. The five span structure is 409-feet long. It replaced an earlier timber structure that was located a short distance downstream from the bridge.

The Yellowstone River Bridge at Gardiner under construction, 1930 (R. V. Nixon Collection, Museum of the Rockies).

By 1932, the Commission abandoned the standard Pratt truss for deck truss bridges in favor of Warren trusses. Between 1932 and 1942, the Commission constructed at least seven deck truss bridges--all located in northwestern Montana. The stronger Warren truss allowed the construction of longer structures. The average length of a deck truss structure was 655.5-feet.

The Yellowstone River Bridge in 1931 (R.V. Nixon Collection. Museum of the Rockies).

Three of the seven bridges cross the Clark Fork River in Missoula and Mineral counties. Except for the Two Medicine River Bridge in Glacier County, all were built by out-of-state contractors. Because of the complexity of the design and site conditions, unskilled labor was unsuitable for the construction of these monoliths. Unlike the more simple through truss structures, deck truss bridges could not be as readily standardized, thereby initiating a revival of site specific bridge design. In 1938, the American Institute of Steel Construction awarded Commission bridge designers a prize for the design a Warren deck truss bridge at West Glacier (the bridge was destroyed in the 1964 flood).[16]

Highway deck trusses are unique to the Montana landscape. Although relatively common to railroad bridges, they are rare for highways. Because of the great size, amount of material and cost, the Commission generally reserved them for use on high and deep crossings where through trusses and the much narrower steel girder and floor beam bridges were unsuitable. Like the reinforced concrete arch bridges of the 1920s, deck truss bridges are significant reminders of the ambitious Montana Highway Commission construction programs of the 1930s and early 1940s.

The West Glacier Bridge (Photograph courtesy of John Morrison).

Pony Trusses

In addition to the through and deck truss bridges, the Montana Highway Commission also constructed pony truss structures. Essentially a through truss without the overhead structural members. Pony trusses were generally located on relatively narrow crossings and consisted of only one or two spans. The bridges were usually supported by wood bents or concrete piers and wood or concrete abutments.

Pony truss bridges were the first type of truss bridge built in Montana. The King or Queen post structures were crude when compared to the sophisticated trusses built by the Montana Highway Commission in the mid-20th century. The Madison River Toll Bridge near Bozeman is a good example of a queen-post pony truss bridge. By the late 19th and early 20th centuries, the bridge companies constructed large numbers of pony truss bridges throughout western Montana (except for the Lower Yellowstone Irrigation Project near Sidney, there do not appear to have been many pony truss bridges constructed in eastern Montana until the 1920s and 1930s). The

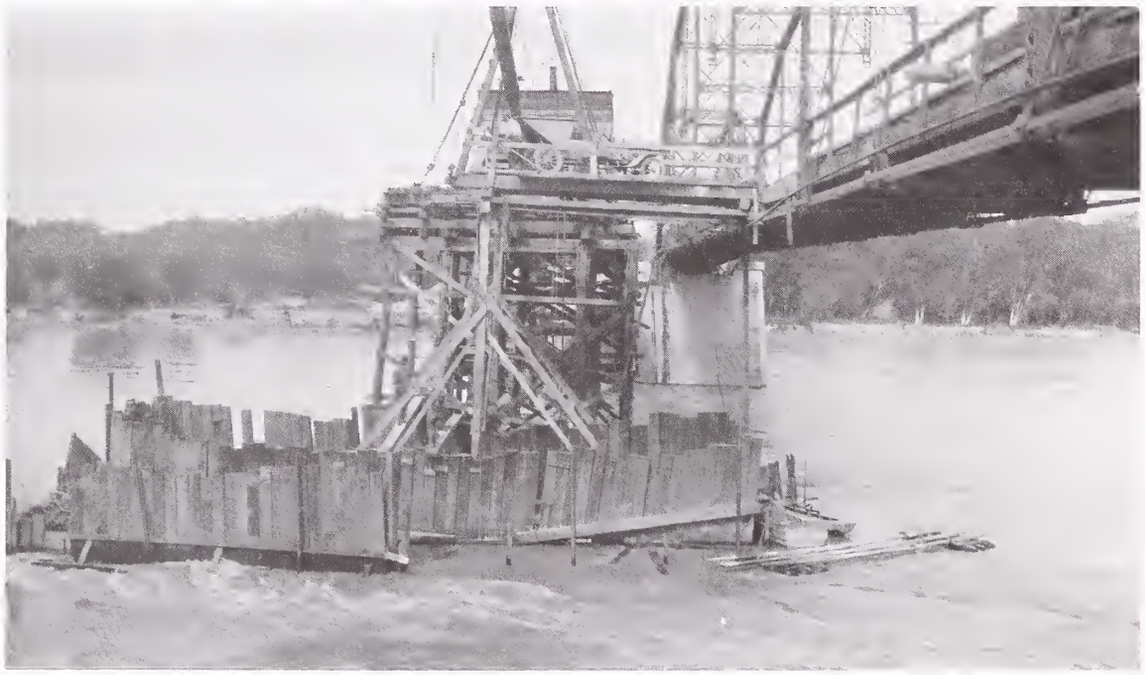
Ten Mile Creek Bridge in Helena is a good example of a bridge company-constructed pony truss bridge.

The Williams Street Bridge in Helena was constructed in 1894 and crosses Ten Mile Creek near Fort Harrison. It is the oldest remaining pin-connected Pratt pony truss in the state.

Shortly after its creation in 1915, the Commission bridge department developed plans for a pony truss structure. Because Warren trusses were better suited to narrow crossings (because of its rigidity), the Commission built large numbers of the bridges. Pratt through trusses were reserved for use on wider crossings that required multiple spans.

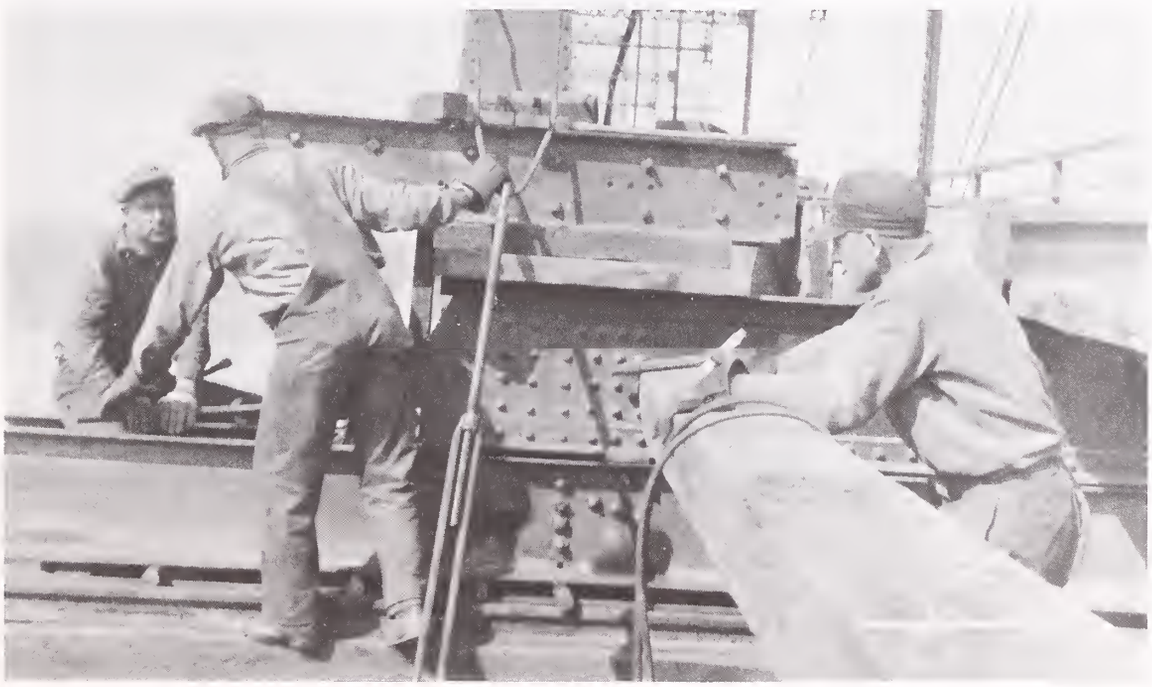
The Commission built only a few simple pony truss bridges in remote agricultural areas after 1946. The Commission relied on the Warren truss for these structures except for two examples of Pratt truss bridges in Stillwater County. The last pony truss bridge was constructed in 1979 by the Montana Highway Department is located in Richland County near Savage. It is a 78-foot long Queen-post bridge that crosses the Bureau of Reclamation's (USRS) main canal in the Lower Yellowstone Project. The USRS bridge near Savage is similar in design to the king post bridges

built by the territorial entrepreneurs of the 1860s and 1870s. It is the simplest of truss forms and the easiest to maintain--a goal sought by engineers in Montana for over a century. A list of National Register of Historic Places-eligible truss bridges is included in Appendix Two.



In 1926 the Montana Highway Commission funded the construction of a new Yellowstone River bridge at Glendive. Now called the Bell Street Bridge, it was the third bridge located at that site (the first was built in 1895). The bridge built in 1900 was used by the Great Falls-based Boomer, McGuire and Blakeslee to transport concrete for the piers. This is one of the cofferdams for the new bridge (Montana Historical Society).

The east approach to the Bell Street Bridge under construction (Ruth Torrence).



Construction crew working on one of the bridge's piers (Montana Historical Society).

Setting the vertical and overhead members (Montana Historical Society).

Nearly completed, the deck will be added next (Montana Historical Society).

The deck has yet to added and the approach spans constructed (Montana Historical Society).

The Boomer, McGuire and Blakeslee Company construction crew, 1926 (Montana Historical Society).

PART 4 - STEEL GIRDER BRIDGES

Steel girder bridges are among the most common type of bridge in Montana. More structurally durable than either concrete or timber, steel girder bridges are an economical and expedient method of spanning both small and large barriers. During the 19th century, the railroads pioneered developments of bridge design and materials. Typically, however, the railroad engineers improved already existing bridge designs (such as trusses) and adapted them for railroad usage. Although the railroads modified and improved existing technology, steel girder bridges were the only bridge form for which the railroads could claim complete responsibility. With the development of steel technology in the late 19th century, the number of girder bridges located on railroads and highways multiplied. The bridges represent the "culmination of the 19th and 20th century railroad influences and the genesis of the modern highway bridge."[1]

Baltimore & Ohio Railroad engineers built the first steel girder bridges in the late 1840s. They were particularly suited to railroad purposes because they accommodated heavy locomotive weights. The girders, however, were more expensive to manufacture and not intially favored by railroad engineers. The cost of transportation, moreover, and the lack of reliable portable field riveting machines also hampered the development of girder bridges. Pin-connected truss bridges continued to dominate the nation's railroad system until after the turn of the century.[2]

Railroad engineers first constructed large numbers of girder bridges during the Civil War. Similar to primitive timber bridges, the design proved a convenient means of spanning small crossings. By the late 1860s, steel manufacturers improved girder fabrication and the number of steel bridges located on the nation's railroad system mushroomed. By 1890 most bridge engineers abandoned iron structural components in favor of steel. The introduction of mass-produced rolled sectional I-beams allowed the economical fabrication of girders in shops. This development caused a boom in the number of steel stringer and plate girder bridges located on the expanding national highway network.[3]

In Montana, the development of steel girder and stringer bridges reflected national and regional economic trends. Essentially a conservative bridge form, the basic design was aptly suited to the state bridge engineers' program for the rapid and economical spanning of Montana's barriers. Although steel truss bridges dominated the state's road system until 1920, the number of girder and steel stringer bridges located on the state's roads steadily grew until 1950. While truss bridges were distinct symbols of the state's economic prosperity, steel girder bridges were the true workhorses of the system providing access to the railroads and markets for thousands of Montana farmers and ranchers.

Approximately 394 steel girder and stringer bridges were constructed by the Commission on the state's highway system between 1901 and 1956. There were three types of steel girder bridges: simple steel stringer structures, plate girder spans and steel girder and floor beam bridges. In Montana, the steel stringer bridge averaged approximately 80-feet in length and structurally resemble timber bridges. Steel girder and floor beam bridges, on the other hand, averaged approximately 320-feet in length and primarily spanned the state's larger rivers. Both types of girder bridges are purely utilitarian structures.

Unlike timber and reinforced concrete bridges, large numbers of steel stringer bridges that pre-date the creation of the Montana Highway Commission are still located on the state's on- and off-system roadways. Between 1900 and 1909, county road crews constructed at least eighteen steel girder and stringer bridges in Montana. Except for one structure, all are single span bridges less than 50-feet long. Sixty-six percent of the bridges are located in Custer County. Others are located in Jefferson, Powder River (which was a part of Custer County until 1919), Park and Stillwater counties. Eleven are steel stringer girder bridges, while one is a steel girder and floor beam structure located north of Basin on Cataract Creek. Except for the Cataract Creek Bridge, all were located on farm-to-market roads and all vary little in design.

The enactment of the 1909 Enlarged Homestead Act sparked an agricultural boom in Montana. To facilitate the movement of agricultural commodities to markets, county governments placed considerable emphasis on the development of farm-to-market roads and bridges. Because simple steel stringer bridges were inexpensive and could be rapidly constructed by small work crews, the new counties built at least 39 of them between 1910 and 1919.[4]

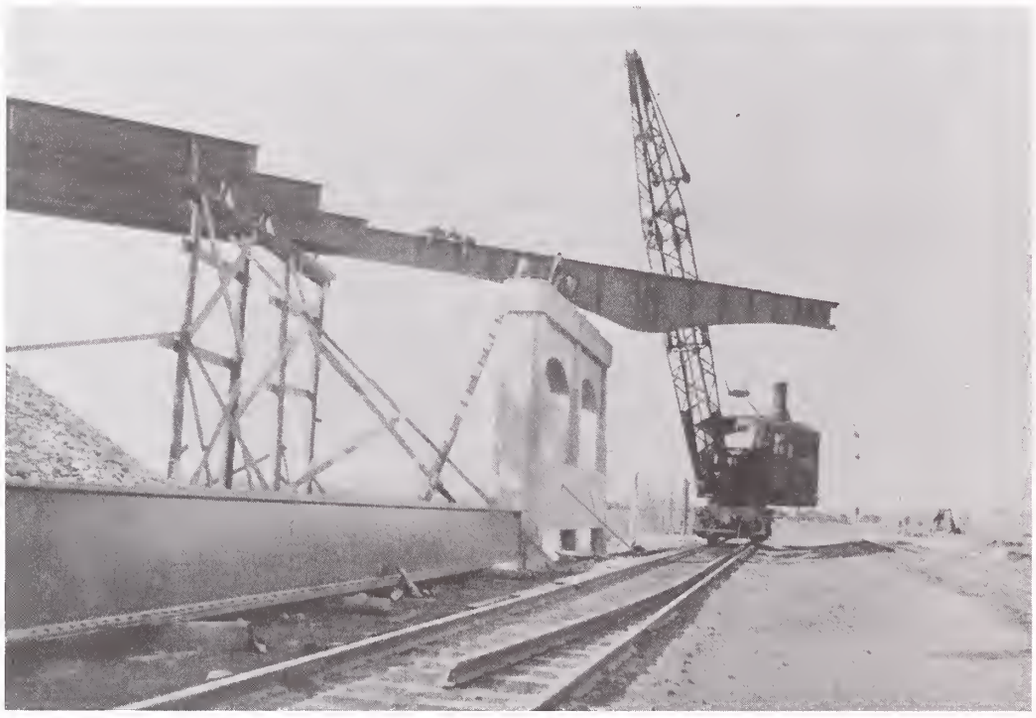
The counties continued to construct these plain steel bridges after the organization of the Highway Commission in 1913. Because small steel girder bridges usually cost less than $500 to build, the counties were not required to obtain standard bridge designs from the Commission or have them inspected by bridge engineers when completed. Nonetheless, all the steel stringer bridges constructed by the counties between 1913 and the establishment of the Highway Commission's bridge department in 1915 were virtual carbon copies of each other--varying only in the length and width of the bridge (only a few have guardrails).

Post-War economic depression and drought ended the decade-long homestead boom in Montana by 1920. Although faced with revenue shortfalls and economic disaster, the counties continued to build steel girder bridges in isolated rural areas. Between 1920 and the end of the depression in 1926, the county's constructed 23 steel girder bridges in the state (compared with fifteen timber bridges). Like their predecessors in the prosperous years before the Great War, most of the bridges were single span structures less than 40-feet long. After the Commission began funding bridge construction in 1926, metal and timber guardrails became standard to the structures. Approximately 52% of the steel girder bridges constructed by the Commission at that time were located on the High Line and in south central and southeastern Montana. By 1928, economic prosperity briefly returned to Montana and the Commission constructed seventeen girder bridges in the populated western counties of the state. The up-swing in the state's fortunes, however, was short-lived as the stock market crash in 1929 and subsequent economic depression nearly destroyed the state's bridge construction program.[5]

Next to timber bridges, steel girder bridges are the most common type of bridge on Montana's primary, secondary and off-system roadways. Between 1930 and the U. S. declaration of war against the Axis powers in 1941, the Commission built at least 162 steel stringer and steel girder and floor beam bridges in Montana. Sixty-four percent of the structures are located on off-system farm-to-market roads (25 are located in Blaine County alone). While the Commission retained timber bridges for on-system primary routes, they reserved steel stringer bridges for the solitary dirt

roads of the state's backcountry.

The 1931 Montana legislature passed a $6 million debenture to combat the effects of the depression and improve the state's road system. Under that funding program the Commission built 135 bridges in Montana--five percent of which were steel girder spans. Like timber bridges, most of the steel girder structures were constructed under the auspices of federal relief programs. Midwestern and West Coast factories manufactured the construction materials. The bridges were built primarily by in-state contractors. Although the New Deal programs waned by the end of the 1930s, the number of bridges constructed in Montana increased. From 1940 to 1941, the Commission built 31 steel girder bridges in the state.[6]



Construction of the Mossmain railroad overpass in Billings, 1936 (Photograph courtesy of Bob Robbins).

During World War II, the construction and maintenance of bridges was limited to those vital to national defense purposes. Easily prefabricated steel girder bridges could rapidly be erected by small construction crews. The Commission built fourteen steel girder bridges in Montana between 1942 and 1945--only 52 timber, seven reinforced concrete and three truss bridges were built during that time. Located primarily in Stillwater County, the bridges carried traffic from the chromium mines near Nye. Because of prefabrication and the simple design, the Commission built steel girder bridges in greater numbers than truss or reinforced concrete bridges during World War II. Unfortunately, the Bureau of Public Roads' and the Commission's policy of minimal construction and maintenance left the state's roads and bridges in poor condition once the war ended in late 1945. Although highway construction significantly increased after the war, it was not until 1949 that the Commission's road and bridge programs once again fully mobilized.[7]

Setting the middle girders of the Mossmain overpass, 1936 (Photograph courtesy of Bob Robbins).

Between 1949 and the initiation of the interstate program in 1956, the Highway Commission constructed 118 steel girder bridges in Montana--mostly on on-system roadways. During this period, the Commission reconstructed many of the roadways built before the 1930s. The Federal-Aid Road Act of 1956, moreover, mandated the up-grade of strategic roads and bridges. As a result, the Commission initiated an ambitious program of paving pre-World War II roads.

In the years just prior to the construction of the interstate highways, the number of new timber bridges dropped significantly (except in 1950, when the Commission built 110 timber structures) and the number of steel girder bridges more than quadrupled. Technological improvements in steel fabrication contributed to the increase. By 1959, however, prestressed concrete bridges predominated on both the interstate and on-system highway system.

Because of the technological improvements and the renovation of the road system, the Commission could construct longer girder bridges in the state. From an average of 112-feet in 1930s, the length increased to an average of 163-feet between 1949 and 1956. The Commission constructed six steel girder and floor beam bridges during that time, including the Huntley Bridge and the massive O.S. Warden Bridge in Great Falls. The length of steel stringer bridges also increased as materials and prefabrication techniques improved. Scattered throughout the state, the bridges supported the economic development of Montana during the 1950s and 1960s.

Twenty-one out-of-state fabricating plants manufactured the components for steel girder bridges in Montana. The prolific Chicago and Seattle-based Bethlehem Steel Company provided the elements for 26 bridges between 1931 and 1941. Typically,

the Highway Department contracted with two steel fabricating companies for each bridge. One company provided the structural steel, while the other supplied the reinforcing steel for the concrete abutments and piers. For example, Bethlehem Steel would manufacture the structural steel for a specific bridge while the Colorado Builders and Supply Company provided the reinforcing steel for the piers and abutments. On another project, Colorado Builders might provide the structural steel and Bethlehem the reinforcement. Unlike timber bridges, the fabricators were not contracted to supply components to a specific number of bridges each year. Instead, the Montana Highway Department let contracts for larger steel girder bridges on an individual basis.[8]

Built by the W. P. Roscoe Company of Billings in 1949, the 1,024 foot Huntley Bridge is a steel girder and floor beam bridge. The Pittsburgh-Des Moines Steel Company of Des Moines, Iowa fabricated the 1,024-foot 8-span structure.

Montana companies dominated the construction of steel girder bridges in the state. Thirty-one in-state contracting firms operated in Montana between 1928 and 1952. While companies from Great Falls, Billings and Butte controlled the market, other firms were located in Helena, Miles City, Livingston, Hysham, White Sulphur Springs, Hamilton, Sidney and Glasgow. The prolific W. P. Roscoe Company of

Billings constructed 13 steel bridges in Montana--mostly during the 1930s and 1940s. Since the Montana Highway Commission did not annually let contracts for girder bridges in groups, no contractor operated exclusively in a given area. The CCC built few steel girder bridges since they required skilled labor.

Eight out-of-state bridge companies operated in Montana during the 1930s and 1940s. The companies constructed 20 bridges located throughout Montana. The most prolific firms were the Hansen & Parr company of Spokane, Rue Construction Company of Bismarck, and the Idaho-based Peter Kiewit & Sons. Other companies were based in Portland, Oregon, Rock Springs, Wyoming and Opportunity, Washington.

Steel Stringer Bridges

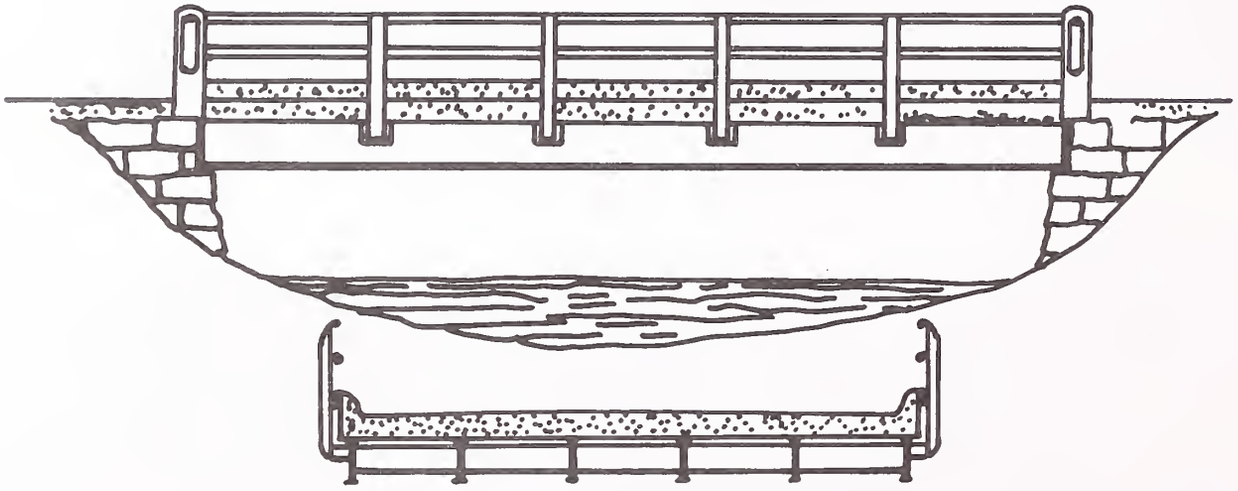
Perhaps the most rudimentary structures on Montana's roadways, multi-beam steel stringer bridges consist simply of girders supported by abutments and, in the case of multi-span bridges, pile bents or reinforced concrete piers. The girders are normally interspaced with wood or steel stringers. The number of girders corresponds to the type of deck. A wood deck requires more girders and stringers than does a concrete slab deck. The abutments are supported by wood or concrete back and wing walls. The concrete or asphalt deck is flanked by reinforced concrete, wood or metal guardrails. Bridges located in isolated rural areas generally had wood decks and no guardrails.[9]

From the perspective of the roadway, these structures are virtually indistinguishable from timber or reinforced concrete bridges. When more than one span was necessary, timber pile bents or reinforced concrete piers supported the structure--depending on site conditions. Since most of the on-system bridges average about 80-feet in length, rocker expansion joints are located on the abutments to compensate for the thermal expansion and contraction of the steel structure. Steel girder bridges under 50-feet in length have no rockers to counterbalance variations in temperature.

The simple design of the bridge type requires little maintenance and is very durable. Its steel construction tolerates higher load limits and is particularly suited to isolated rural areas. Maintenance to these bridges is mostly limited to the reinforced concrete abutments and the wood components of the structure. Other than the guardrails and rocker joints, there is essentially no variation in the design of the bridges and few have decorative detailing. The uniformity of appearance of this type of bridge has led one engineering historian to call them "technologically indistinct" and not representative of any major development in bridge construction.[10]

There are 366 steel stringer bridges located on Montana's primary, secondary and off-system roads. The bridges have functioned in much the same capacity as timber bridges. Easy to construct, they were less expensive and just as durable as truss bridges. Most of the bridges constructed during the first decades of the 20th century are still in use. Most are single span structures located in northern and eastern Montana. Unlike timber bridges, however, steel stringer bridges were built primarily on county farm-to-market roads in the state's remote rural areas. Only 40% of the bridges are located on the primary and secondary systems. While truss and timber bridges dominated bridge construction in the late 19th century and the

first four decades of the 20th century, the number of steel girder bridges rose steadily until the 1940s. By the late 1950s, reinforced and prestressed concrete structures predominated on the state's roadways.



Montana Highway Commission Bridge Department's standard steel stringer bridge.

Plate Girder Bridges

Plate girder bridges consist of beams with steel plates and angles welded, bolted or riveted to the beams to form I-beam girders. Until steel welding technology was perfected in 1954, the plates were riveted to the beams. Although plate girders were common to steel truss bridges constructed before 1925, there are few plate girder bridges that date from before the 1940s. Many plate girder bridges are "haunched", meaning that the structures are deeper at the piers where the extra strength is needed. In Montana, most of the longer steel girder and floor beam bridges are also "haunched." The plate girder bridge worked well for variable depth crossings. For long span plate girder bridges (and grider and truss bridges), one end of the bridge was fixed to the abutment while the other end was allowed to slide on rollers or rockers. All steel bridges over 60-feet in length were provided with rollers or rockers to compensate for thermal expansion.

Railroad engineers first developed plate girder bridges during the early 1840s. Since timber bridges were not suitable for heavy live loads and truss bridges were too cumbersome for short crossings, Baltimore & Ohio Railroad engineers developed the more utilitarian plate girder bridge. Initially it consisted of iron components, but the engineers quickly adapted the newly developed steel technology to girders by 1861. The number of plate girder bridges increased as improvements in steel production became available to the railroad companies.[11]

Until the development of the rolling mill manufacturing process in the late 1860s, the railroads generally used plate girder bridges for short spans. Before 1920, structural limitations limited the bridges to spans of 70 or 80-feet. Prior to the early 1930s, plate girders functioned as components (i.e. laterals and diagonals) to the more complex truss structures By the early 1930s, technological improvements in

steel fabrication allowed the construction of plate girder bridges over 200-feet in length.[12]

The Blackfoot River Bridge at Potomac.

Because of fabrication refinements in the late 1890s and early 1900s, mass production of prefabricated I-beam girders increased steadily. In Montana, however, county crews and bridge companies constructed before 1926. Prefabricated I-beams were cheaper and easier to work with than the more cumbersome plate girders and Montana bridge builders subsequently utilized them in great numbers. Although common to the state's railroads, there are few pre-World War II plate girder bridges located on the state's road system.

The largest vehicular plate girder bridge in the state is located on Montana Highway 200 near Potomac in Missoula County. Built by the Portland Bridge Company in 1947, the bridge crosses the Blackfoot River. The three-span structure rests on two solid concrete piers and two abutments; it is 246-feet long and 27.3-feet wide. The bridge was fabricated by the Carnegie Illinois Steel Corporation of Chicago.

Steel Girder and Floor Beam Bridges

The Montana Highway Commission's Bridge Department initially lacked a steel bridge design that was capable of carrying heavy loads over wide river or stream crossings. By the mid-1920s, the Department designed the steel girder and floor beam bridge to convey heavy traffic on the state's primary road system. The prefabricated components could easily be transported to the construction site. Unlike the truss bridges (which the girder bridges replaced), there were no overhead clearance limitations. Until the appearance of prestressed concrete in the late 1950s, steel girder and floor beam bridges were the penultimate bridge form in Montana for large river crossings.

The railroads constructed the first steel girder and floor beam bridges in Montana in the late 1880s. The design particularly suited them since the bridges could withstand fast moving heavy traffic. The Commission constructed twenty-nine highway steel girder and floor beam bridges in Montana between 1909 and 1956. While steel stringer bridges functioned for crossings of 130-feet or less, the steel girder and floor beam bridges averaged approximately 320-feet in length. Until recently, the longest steel girder and floor beam bridge in the state was the 2,093-foot O.S. Warden Bridge in Great Falls.

A steel girder and floor beam bridge in the initial stages of construction. Some of the concrete piers have been poured, except for the center pier--the coffer dam is in the process of being pumped free of water. It is not known where this bridge was located, but a four or five span steel through truss bridge is located in the background (Robert Blakeslee Photograph).

Since the form did not lend itself easily to narrow crossings, approximately 60% of the steel girder and floor beam bridges are located on primary and secondary roadways. Most of this type of bridge are located on major rivers such as the Missouri, Yellowstone and Flathead, while the majority are located in south central, southwestern and northwestern Montana. Jefferson County crews constructed the

first vehicular steel girder and floor beam bridge in 1909 on Cataract Creek northeast of Basin. The 40-foot bridge provided access to the silver and gold mines in the nearby Elkhorn Mountains.

Once the piers were constructed, workers then began to set the girders of the bridge (Blakeslee Photograph).

The first Montana Highway Commission-sanctioned steel girder and floor beam bridge was constructed by Lincoln County and the Anaconda Copper Mining Company (ACM) in 1914. The single-span bridge incorporated many of the standard design features that the Commission would later include on future structures. While the Commission built over 1,191 multi-beam girder, truss and timber spans between 1930 and the outbreak of the Second World War in 1941, they built only fifteen steel girder and floor beam bridges during that time. Most were over 200-feet long with one--the South Fork of the Flathead River Bridge at Hungry Horse--reaching 592 feet.

The Commission built nearly one hundred steel girder and floor beam bridges after the initiation of the interstate highway program in 1956. While prestressed concrete bridges functioned mainly as overpass structures, the steel girder and floor beam bridges continued to serve as crossings for major rivers. Between 1957 and 1991, 83 bridges of this type were built by the Department and are associated with the interstate system.

The final stage of construction included the addition of the floor beams and braces before the deck was emplaced. This bridge is located approximately five miles north of Belfry on Montana Highway 72 (Robbins Photograph).

PART 5 - CONCRETE BRIDGES

Until recently, reinforced concrete bridges were not a major factor in the early development of Montana's highway system. While a fairly easy medium to utilize for bridge building, the construction of forms required skilled labor. Good sources of aggregate were also a primary consideration before a reinforced concrete bridge was constructed (poor aggregate is the main reason why there are few reinforced concrete bridges in eastern Montana). In many states, concrete functioned in much the same capacity as timber did in Montana for bridges. Reinforced concrete bridges represented permanency, while timber was more symbolic of transition. While there are nearly 1,000 timber bridges still in use on the primary and secondary systems in the state, there are only 403 reinforced concrete bridges located on Montana's transportation network. The majority of reinforced concrete bridges in Montana are simple T-beam, slab and prestressed structures--most built after 1956. There are only eight reinforced concrete arch structures in the state. The development of reinforced concrete is a relatively recent phenomenon in the United States and Montana.

Although first proposed by Ralph Dodd in 1808, reinforced concrete construction was not feasible until 1824 when Joseph Aspdin produced the first portland cement in England. As a result, Europeans initially developed reinforced concrete technology in the late 19th century. It was later refined in the United States during the first decades of the 20th century. R. Jean Monier manufactured concrete flower pots reinforced with wire mesh in France in 1867. By 1879, François Hennebique fabricated reinforced concrete slabs using Monier's system. The first reinforced concrete bridges were short spans designed for railroad and pedestrian use.[1]

American civil engineers experimented with reinforced concrete technology during the late 19th century, but did little to improve the medium or broaden the understanding of the material. Shortly after David Saylor patented an American form of portland cement in 1871, Thaddeus Hyatt and William E. Ward promoted the advantages of concrete T-beam bridges for highway purposes. The structures proved an effective and relatively economical method of bridge construction for spans less than 70 feet. In 1884 Ernest Ransome patented the twisted square bar for the reinforcement of concrete structures; five years later, he constructed the first reinforced concrete bridge in the United States.[2]

Because engineers did not fully understand the nature of reinforced concrete, the Austro-Hungarian government initiated a five year program in 1880 to measure the material's design and functional capabilities. Under the program, Joseph Melan patented the use of parallel metal I beams embedded in concrete for bridge construction in 1885. Essentially a metal arch with a concrete veneer, "Melan System" bridges "heralded a new and unimaginative era in bridge design." The first Melan System bridge in the United States was constructed by Fritz von Emperger in Iowa in 1893. Used primarily for highway bridges, Melan's design was the basis for hundreds of reinforced concrete bridges constructed in the United States between 1893 and the early 1920s. While common in the Midwest and on the West Coast, there are no known Melan System bridges in Montana.[3]

In the United States, progress in concrete engineering was steady, but unspectacular, in the late 19th century. During the first two decades of the 20th century, most of the states created highway departments and consolidated their myriad roads into a

federally-recognized transportation network. Because of the tremendous expansion, economical techniques were needed to quickly bridge barriers on the fledgling road systems. In many areas of the country, reinforced concrete was ideally suited to that need.

During the first two decades of the 20th century, the concrete industry developed standard designs for reinforced concrete bridges. The standards greatly aided the fledgling highway commissions throughout the United States. The most significant advances were made by Midwest and west coast bridge engineers. The Montana Highway Commission, however, tended to be conservative in their use of the material.[4]

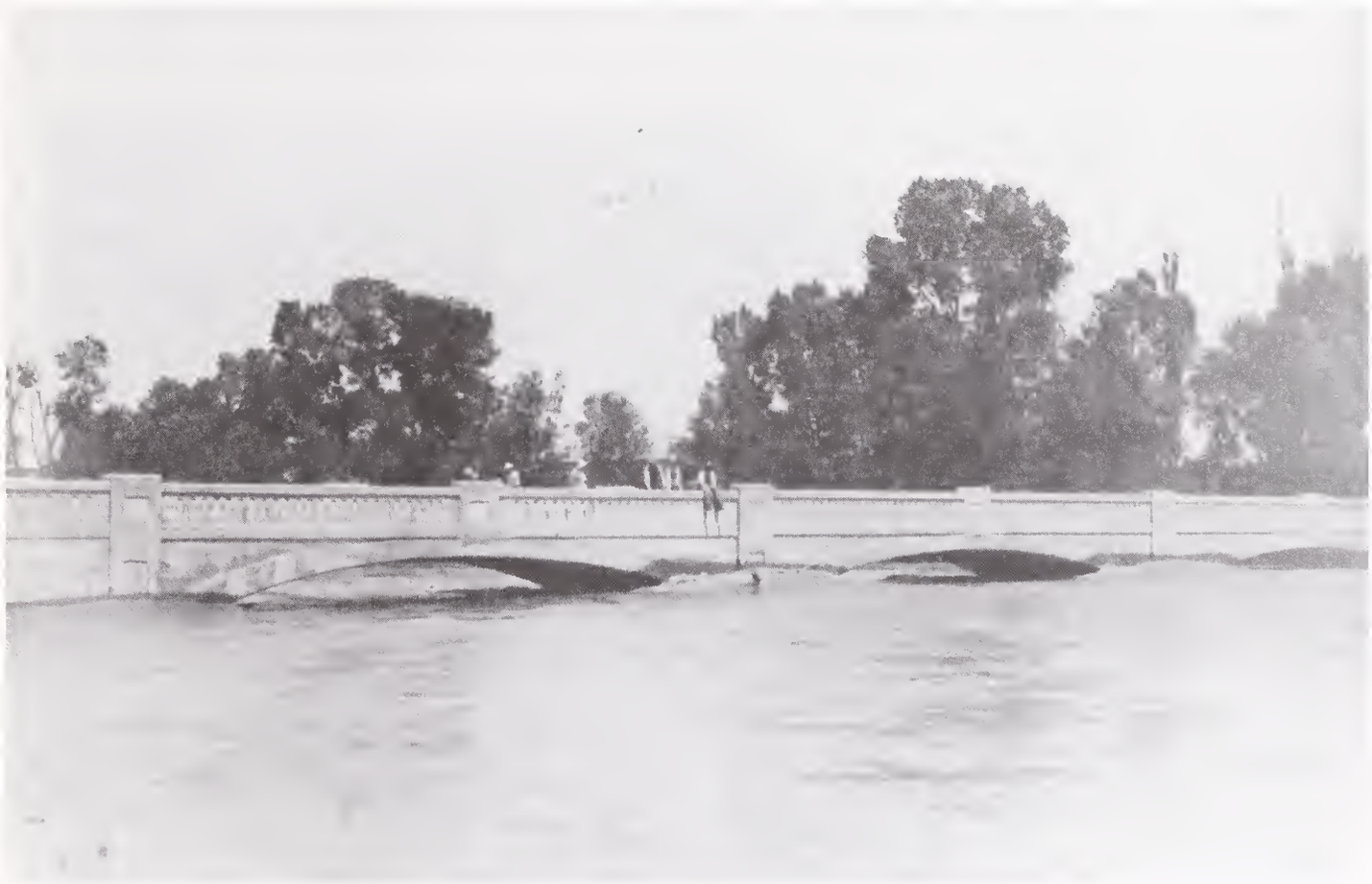
Montana Highway Commission bridge department engineers standardized reinforced concrete bridge designs as they did timber and steel structures. With guidelines established by the American Concrete Institute (ACI) between 1909 and 1916, the bridge department developed designs for reinforced concrete T-beam and slab bridges in the 1920s. Unlike the impermanent timber bridges, the Commission designed reinforced concrete bridges as permanent structures.

The T-beam bridge was the most common reinforced concrete design on the Montana highway system between 1912 and 1956. It was a relatively simple structure that usually consisted of a concrete deck supported by two reinforced concrete beams. The low concrete guardrails were usually decorated with rectangular indentations that simulated a balustrade. Even more fundamental in design, slab bridges consisted of a reinforced concrete slab supported by concrete abutments. Like the T-Beam design, the slab bridge was often flanked with low decorative concrete guardrails. The Commission usually constructed the structures where site conditions prevented the construction of timber bridges (i.e. the stream bed was too compacted to drive piles) and suitable aggregate for the concrete was readily available.[5]

Unlike the T-Beam and slab bridges, reinforced concrete arch bridges in Montana were more complex and monolithic. Because of the greater cost and skill needed to build such bridges, however, the Montana Highway Commission built only three large arch bridges in the early 1920s before abandoning the design in favor of truss, timber and girder bridges.

Concrete Arch Bridges

At the turn of the century, the majority of reinforced concrete bridges in the United States were arch structures that mimicked masonry-arch spans. Whereas concrete allowed considerable freedom in design, American bridge engineers initially showed little inclination or desire to break with tradition on arch bridges. Although the reinforced concrete industry boomed in the United States during the first two decades of the 20th century, except for in Carbon County, there was no significant concrete bridge construction in Montana during the same period. Steel truss bridges were more symbolic of economic prosperity than relatively mundane and generally aesthetically unappealing concrete structures. While bridge companies built large numbers of concrete bridges in the East and Midwest, there are only two concrete arch structures in Montana constructed by a bridge company prior to the creation of the bridge department in 1915.[6]



The Fromberg Bridge during high water in 1918 (Photograph courtesy of Violet Papp).

Although the Commission's bridge department standardized designs for timber, steel and small reinforced concrete bridges, it did not develop plans for monumental concrete bridges. Instead, the department hired private firms to design the multi-span structures. During the first decades of the 20th century, engineers advocated the use of reinforced concrete for bridge construction. Although they recognized the potential of the medium, bridge engineers, at first, tended to be more conservative in their designs. Though the designers advocated the arch as being the most proven method for bridge spans, the method by which they approached the design was distinctive.

Bridge engineers scorned the classically-influenced monolithic designs of the 19th century. Instead, they favored the Art Deco, Art Nouveau and Craftsman movements of the early 20th century. Ribbed open-spandrel concrete arch bridges represented the transition from the classically-influenced monolithic arched structures of the 19th century to the more modernistic 20th century designs. Engineers, such as Henry Tyrell and Charles Whitney, urged the construction of reinforced concrete bridges with separated ribs, open spandrels, projecting sidewalks and overhanging roadways. Bridge engineers, thereby, could emphasize both form and function by

exhibiting the structural elements of the bridge. Since efficiency and economy were also important elements, the style was ideally suited to the era's sensibilities. The Tenth Street Bridge in Great Falls and the Carter Bridge in Park County are surviving examples of this style in Montana.[7]

The Carter Bridge, located three miles south of Livingston, was the last open spandrel ribbed arch reinforced concrete bridge built in the state.

The Carter Bridge is located four miles south of Livingston on the Yellowstone River on the Yellowstone Trail (old US Highway 89). The bridge was constructed by B. N. Crenshaw of Livingston in 1921. The Carter Bridge is 270-feet long and 25'2" wide with two 12-foot driving lanes. The arches are double-ribbed and have open spandrels and rest on two concrete piers.

After the completion of the Carter Bridge in 1921, the Commission abandoned large reinforced concrete bridge design. The labor cost of the bridges was prohibitive and its use limited to wide, shallow crossings. Instead, the Commission relied on smaller T-beam and slab bridge designs. In 1928, however, the Commission authorized the construction of two small single-span concrete arch bridges in Glacier County. Located near the eastern boundary of Glacier National Park on US Highway 89, the Commission likely constructed the bridges to enhance the scenic

quality of the area. Both bridges are located on tributaries of the Milk River and were constructed by Evarts Blakeslee--the construction supervisor of the Tenth Street Bridge in Great Falls.

Because of its "classic" appearance and its ability to be molded and formed, concrete was also valued by planners for its scenic quality. Concrete arches (or a facsimile) were used at Lewis and Clark Caverns and Glacier National Park. Single-span concrete arch structures were also located on important tourist routes to the national parks. The South Fork of the Milk River Bridge near Kiowa Junction in Glacier County, is a good example of this type of structure.

Between 1928 and 1945, the Commission built no concrete arch bridges. The Vine Street Bridge over Rattlesnake Creek in Missoula was the last concrete arch bridge constructed by the Commission in Montana. Built in 1945, the bridge is a simple slab bridge with an arched superstructure. It is 90-feet long and 37.6-feet wide with two 4-foot sidewalks flanking the 26-foot roadway. The bridge has metal pipe guardrails and is not ornamented.

The Vine Street Bridge was the last reinforced concrete arch structure built by the Montana Highway Commission.

T-Beam Bridges

Simple reinforced concrete T-beam bridges are common to Montana's roadways. Until the advent of prestressed concrete after 1957, T-beam bridges were the most standard type of concrete bridge constructed by the Commission. First developed in the mid-1870s by Thaddeus Hyatt, the design derives its name from the "T"-shaped configuration of the support beam. The head of the "T" is incorporated into the deck slab of the structure which also functions as the floor of the bridge. While the reinforced steel reinforcement bars were fabricated as a separate unit, the "T" beams and deck slab were cast as a single section at the construction site. Though not as easily constructed as timber bridges, T-beam bridges were more suitable to areas of heavy traffic, required skilled labor for their construction and were considered to be permament structures.[8]

European and American engineers refined reinforced concrete technology during the last three decades of the 19th century. In 1877, Thaddeus Hyatt published *An Account of Some Experiments With Portland Cement Concrete Combined With Iron as a Building Material.* Regarded by some experts as the primary document in the development of reinforced concrete, the treatise described the design of slab, box girder and T-beam bridges. Hyatt emphasized the suitability of reinforced concrete T-beam bridges for highways because of their rudimentary design and economy of construction. By the turn of the century the use of concrete boomed because of improvements in portland cement and reinforcing steel. By the 1910s, T-beam bridges were common to roadways throughout the country.[9]

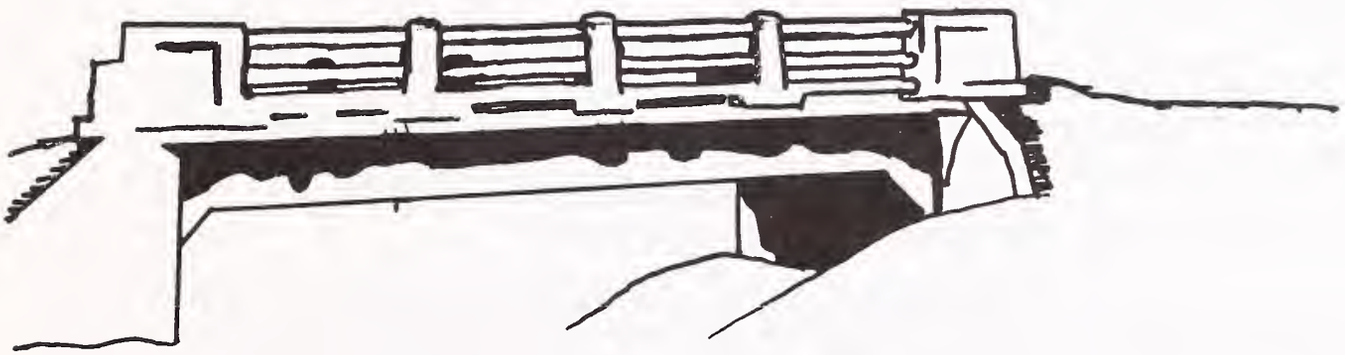
Although not as prominent as the concrete arch spans, T-beam bridges were more practical for bridging small crossings in the United States. They were usually nondescript with few decorative elements. Like timber bridges, once engineers refined the design there was essentially no deviation from the standard style other than in length and the number of spans. The simplicity of the design made T-beam bridges well suited to the rapidly expanding highway systems in the United States during the first half of the 20th century.

In Montana, however, reinforced concrete T-beam bridges were the exception rather than the rule. While the Commission built nearly 1,000 timber bridges in the state between 1900 and 1956, they constructed only 110 T-beam spans during the same period. Evidence suggests, moreover, that the Commission did not complete a standard concrete T-beam bridge design until well into the 1920s (unlike the timber, truss and girder designs). The bridge department had more than its fair share of engineers well versed in the design of truss bridges, but there does not appear to have been anyone on staff who specialized in reinforced concrete until the 1920s.

There are approximately ninety-five pre-1956 reinforced concrete T-beam bridges located on on- and off-system roadways in Montana. The Highway Commission constructed about 73% of the bridges between 1930 and 1936. Most were constructed in 1931--two years prior to the initiation of Roosevelt's New Deal programs. Most of the bridges are located in western and south central Montana. Although the length of the structures varied according to location, the average length of concrete T-beam bridges was nearly 105-feet and the width was usually just over 29-feet. The longest T-beam bridge is located in Gallatin County. The eight-span structure is 345-feet long and crosses the Montana Rail Link railroad tracks near

Logan. The shortest structure is 22-feet long and is located near Grantsdale in Granite County.

Fabricating companies located in located in Washington, Colorado, Minnesota, Oklahoma and Iowa manufactured the reinforcing steel used in Montana's concrete bridges between 1920 and 1945. Like the timber bridges, the Commission awarded contracts to reinforced steel manufacturers on an annual basis instead of individually. The most prolific fabricator was the Seattle-based Pacific Coast Steel Corporation. For a six year period between 1930 and 1936, the company provided material for nineteen structures--located primarily in western Montana. The Colorado Fuel and Iron Company of Pueblo provided steel for twelve T-beam bridges during the same period. Other fabricators included the Colorado Builders Supply Company of Denver, the Paper Calmenson and Minnesota Steel & Machine Company of St. Paul, Minnesota, Kolman Steel Corporation of Minneapolis and the Seattle branch of the Bethlehem Steel Company.



The Standard Commission reinforced concrete T-beam bridge design. The design was used for over 400 bridges between 1920 and 1955.

Between 1915 and 1956, thirty Montana companies constructed reinforced concrete bridges in the state. Eight companies were based in Butte and five in Great Falls. Only one company--Rue Brothers of Miles City--was based in the eastern part of Montana. In addition, federal highway crews constructed five bridges--mostly on forest highways. Unlike the timber bridge construction program, no single company dominated the industry.[10]

Six out-of-state companies also constructed bridges in Montana during the 1930s. The most active out-of-state contractor was the Dakota Concrete Company of Minot, North Dakota. As with the timber bridges, local contractors and small out-of-state companies were responsible for the construction of relatively small timber and concrete spans.[11]

Between 1920 and 1930, the Commission built only 11 T-beam bridges on Montana's highway system. During the early 1930s, however, T-beam bridge construction increased as the depression in the timber industry made components for wooden bridges scarce. The perceived permanency of concrete, moreover, made the material appealing to the financially strapped Montana Highway Department. Between 1931 and the initiation of the New Deal in 1933, the department constructed 43 T-beam bridges. Butte-based companies constructed most of the bridges. Although timber bridge construction expanded in 1933, concrete T-beam construction remained constant.

The Commission built no T-beam bridges in 1937 and only one in 1938. Unlike timber bridges, most concrete T-beam bridges were located in the western one-third of the state. Although capable of carrying heavier loads than timber bridges, reinforced concrete structures were not concentrated in the mining and smelting areas of Butte and Anaconda. Twenty-one percent of the bridges, in fact, were located in Cascade, Lewis and Clark and Gallatin counties.

The first reinforced concrete T-beam bridge in Montana was privately constructed in Carbon County in 1913. Gibson Concrete Works of Fromberg built the Bluewater Creek Bridge about nine miles southeast of the community. The company was the only cement manufacturer in the county and likely supplied the material to all the reinforced concrete bridges in the area until the 1920s. The one-span structure is 30-feet long and 17.5-feet wide. The bridge was probably built to facilitate the transportation of sugar beets to the beet dump in Fromberg.

Although not designed by the Montana Highway Commission, the bridge includes many of the features that would become standard to the design by the mid-1920s. These included low concrete guardrails with rectangular indentations to resemble a balustrade. The bridge rests on earth abutments and concrete wing walls. Two other T-beam bridges were constructed in Carbon County by 1917--the East Rosebud Creek Bridge in Roscoe (1915) and the Red Lodge Creek Bridge north of Red Lodge (1917). All three bridges are still in use on county roads.

The Commission built only six T-beam bridges in the early 1920s. The decade was a time of experimentation as the Commission standardized plans for timber, truss and girder bridges. The Commission did not standardize concrete bridge designs until late in the decade. Once developed, however, there was little change in the style until the 1960s.

The Bluewater Creek Bridge in Carbon County. Constructed in 1913, the structure was the first reinforced concrete T-beam bridge built in Montana.

The Thirties and the New Deal

After the stock market crash and resulting economic depression in 1930, the Montana legislature enacted a debenture to provide $6 million for road construction in the state. Timber shortages and the lack of a comprehensive highway construction plan contributed to a reduced construction program. Rather than expand the highway network, the Commission concentrated on the improvement and maintenance of roads and bridges near the urban areas in western Montana. Improvements to bridges included the replacement of aged timber structures with reinforced concrete bridges.

Commission road crews constructed five T-beam bridges in Montana in 1930. In 1931, however, the number increased to 19 bridges--primarily located in twelve counties in western Montana. The design changed little from the time of its standardization by the Commission's bridge department in 1924. The bridges varied only in the type of reinforced concrete bents and the guardrails.

Between 1933 and the country's entry into World War II in 1941, the Commission constructed 28 T-beam bridges. Most of the bridges were built with the financial support of the New Deal's make-work programs. Since reinforced concrete required skilled labor the WPA constructed few T-beam bridges. A reinforced concrete bridge could be built by an experienced crew in about a month. The reinforcing steel cost anywhere from 4½ to 6¢ per pound while the Class "A" concrete necessary for the superstructure of the bridge cost eighteen to twenty dollars a yard (the contractors felt the cement companies were "robbing" them if it cost more than $20 a yard). When constructed by the Commission, reinforced concrete was usually reserved for bridges greater than sixty feet. Unlike timber bridges, T-beam bridges during the 1930s crossed larger creeks and railroad grades. Of the 28 bridges built by the Commission between 1933 and 1941, thirteen are railroad crossings.[12]

The Conley Street Bridge in Deer Lodge was constructed by Montana State Prison inmates in 1913.

The Second World War signaled the end of the Montana Highway Commission's bridge-building program in 1942. Highway work was limited to maintenance of roads and already existing structures. Although the Commission built 36 timber bridges on the newly-designated defense highway system, they constructed only two T-beam bridges during the war years. The 176-foot long Stillwater Bridge at

Nye was constructed in 1945 to accommodate trucks carrying chromium from the Benbow and Mouat mining complexes in the Beartooth Mountains. The bridge was the last reinforced concrete T-beam structure built by the Commission until 1952.

The number of T-beam bridges constructed by the Commission during the late 1950s dropped in favor of prestressed concrete bridges. The inception of the interstate program in 1956 provided new impetus for the construction of this type of bridge. Between 1957 and 1973, the Highway Commission built 60 T-beam bridges--primarily on off-system roadways. Between 1974 and 1990, however, the Commission built 83 T-beam bridges in the state. The design of T-beam bridges, however, did not significantly change from the design developed in the late 1920s. Bridge designers, however, abandoned the traditional concrete guardrails in favor of metal rails.

The Conley Street Bridge, circa 1914 (Montana Historical Society).

There are 34 continuous concrete T-beam bridges located on the state's primary and secondary roads. Because of the expense, they were not widely accepted by bridge engineers as viable methods of crossing large barriers unless the river or creek was of variable depth. Convict labor built the first continuous concrete T-beam bridge in

Montana in 1913. The Conley Street Bridge is located adjacent to the old Montana State Penitentiary complex in Deer Lodge. It crosses the Clark Fork River and provided access to the prison from the Milwaukee Road and Northern Pacific Railroad train yards.[13]

The concrete structure replaced a wooden bridge with trestle-style pile bents that was constructed on the site in either the 1870s or 1880s. In 1911, warden Frank Conley proposed the construction of the bridge using prison inmates as the labor force. He estimated the cost of the bridge at approximately $1,600 with the cost partially defrayed by the Northern Pacific and Powell County. When completed in 1913, Conley declared that "on this site now stands a handsome bridge, 150 feet long and 20 feet wide, with three spans of 50 feet each on a level grade, a necessary convenience for the transportation of material for the prison."[14]

Reinforced concrete T-beam bridges were the first concrete bridges standardized by the Commission's bridge department. Although relatively easy to construct, the need for skilled labor to build forms and good sources of aggregate for the concrete prevented its acceptance by Montana bridge engineers. Timber bridges were easily (and cheaply) fabricated and could be constructed by unskilled labor. Concrete T-beam bridges, however, were more suited to crossings greater than 100-feet, but proved not necessarily more durable than timber bridges. The Montana Highway Commission used T-beam bridges where they were needed--primarily in western Montana. The development of reinforced concrete T-beam bridges was an important step to the standardization of bridge designs on Montana's roadways.

Slab Bridges

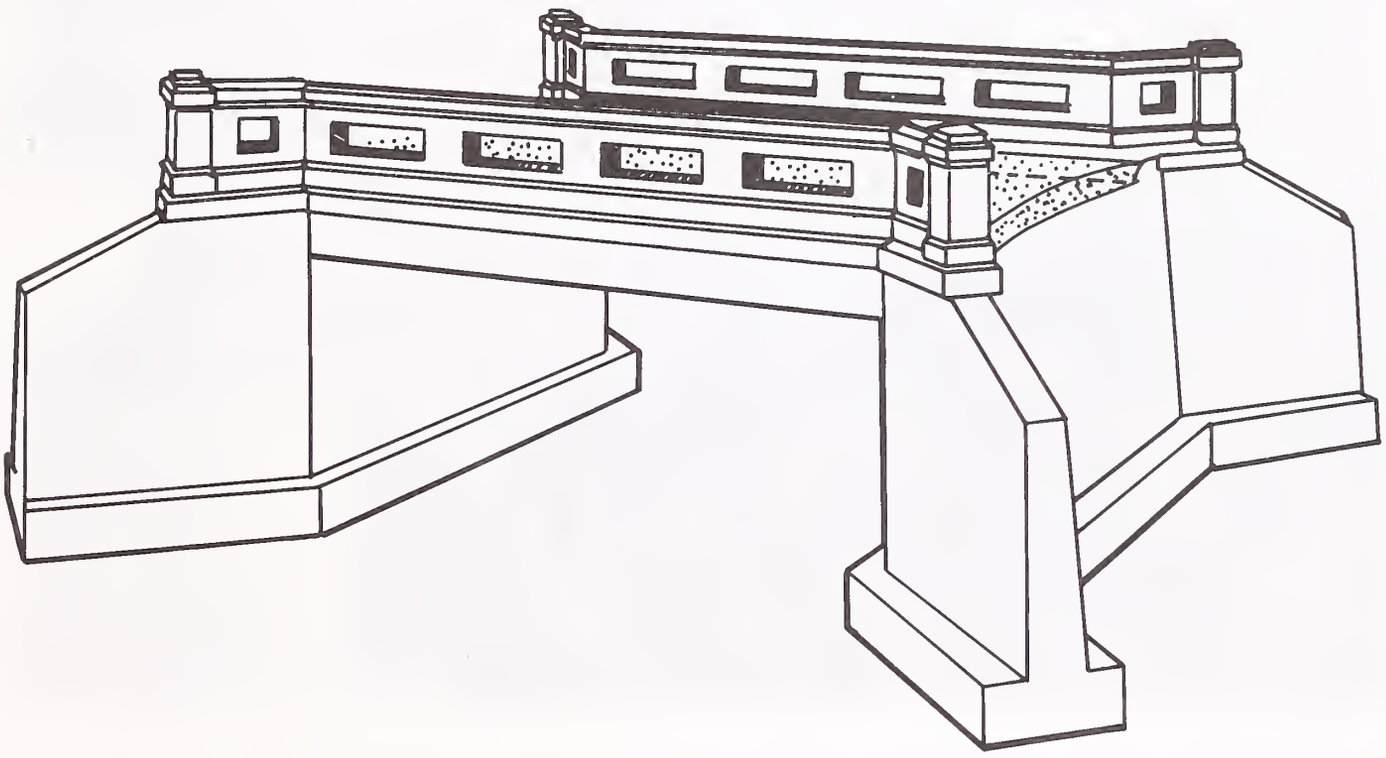
While reinforced concrete T-beam bridges predominated on the state's primary and secondary roads, reinforced concrete slab bridges were also important to the development of transportation in Montana during the 1920s and 1930s. Although the Commission constructed slab bridges in less numbers than T-beams in the 1930s, today they are second in number only to prestressed concrete structures located in the state.

Constructed as either a single unit or as a series of slabs placed parallel with the roadway alignment, reinforced concrete slab bridges are simple in design and are more economic than arch or T-beam bridges. The construction of the forms for slab bridges, moreover, did not require highly skilled labor and was relatively inexpensive. Because of structural limitations, slab bridges were suitable only for narrow crossings. Before the 1950s, builders usually cast the slabs in place. Since the form was uncomplicated it required less labor for the installation of the reinforcement. The slab structure was also easier to widen since it did not impair the durability of the bridge since the pier could be extended to accommodate more slabs.[15]

Although François Hennebique developed a method of reinforced concrete slab construction in 1879, he did not patent the design in the United States until 1892. By the late 1890s, however, Fritz von Emperger pioneered a different type of reinforced concrete slab construction that was based on Joseph Melan's use of steel I-beams for reinforcing. Since Melan (and von Emperger) relied heavily on I-beams

to reinforce the concrete, it made the material unwieldy and, therefore, expensive for general use. The nature of the slab made the spanning of distances greater than 20-feet impractical because of the weight of the structure. While there are many Melan System reinforced concrete arch bridges in the midwest, there are few slab bridges based on his principle.[16]

In 1909, C. A. P. Turner revolutionized reinforced concrete slab construction with the addition of columns to support the slab. Within a few years, however, the column was discarded as engineering and materials improved. Consequently, in many areas of the United States, concrete slab bridges displaced the more rudimentary timber bridges by the 1930s. In Montana, bridge engineers did not widely accept slab bridges, but preferred the more inexpensive and easily accessible timber to concrete for the bridge construction. Whereas prison convicts built the first concrete slab bridge in 1912, by 1950 only 28 slab bridges had been constructed by the Commission on the state's primary and secondary roads.[17]



The Standard Montana Highway Commission reinforced concrete slab design.

Convict labor built the first reinforced concrete bridges in Montana in 1912. Only one bridge, however, was a concrete slab. The Warm Springs Creek Bridge at the Montana State Hospital in Deer Lodge County is a simple one-span bridge. The bridge is 19-feet wide and 27-feet long; it has concrete wing walls and a wood sidewalk. The construction of the bridge coincided with the erection of buildings located on the campus of the state hospital.

The use of convict labor for road and bridge construction was an important facet of early attempts by the Montana counties to improve their transportation systems. Montana State Penitentiary warden Frank Conley believed the experience gained by convict road builders would be useful to them once released from prison. The counties hired convicts to construct short lengths of roadway and small bridges within their districts. Although the 1916 Federal-Aid Road Act did not provide funds for construction projects, it did purchase horses and construction equipment for use by the convicts. Between 1913 and about 1917, the convict road gangs contributed significantly to the improvement of the state's transportation system.[18]

The Warm Springs Bridge was constructed by prison convicts in 1912.

The Bridge Department standardized the design of slab bridges by 1921. While there are exceptions, most of the department's slab bridges averaged 22-feet in length and from 20 to 25-feet in width. There were no decorative elements to the simple structures other than open or closed railed guardrails. The Commission constructed six slab bridges in the state between 1921 and 1930. Located in six counties throughout the state, four of the bridges were built in 1921 and varied between one to three spans (one bridge located in Dawson County consisted of six spans and is still the longest concrete slab bridge in Montana).

Three companies manufactured the components for reinforced concrete slab bridges during the 1930s: The Bethlehem Steel Company and Pacific Coast Steel Corporation of Seattle and the Colorado Builders Supply Company of Pueblo. The companies also supplied steel for T-beam bridges during the 1930s. Although many of the contracting companies who constructed T-beam bridges also built concrete slab bridges in the 1930s, most of the slab bridges were constructed by federal and county work crews.[19]

Like T-beam bridges, the Commission did not build large numbers of reinforced concrete slab bridges during the late 1930s. While they built nearly 100 T-beam bridges during the decade, the Commission built only eighteen slab bridges during the same period. Sixty-six percent were built by the Commission in 1930 and 1931; all but four of the bridges are located in southwestern Montana. Because of the cost of construction, the design was suited to unskilled labor. The five slab bridges constructed during the New Deal Years appear to have been built by county construction forces.

Highway Commission activities during World War II were limited primarily to the maintenance of existing roads and bridges. Two reinforced concrete slab bridges, however, were constructed in 1944 and 1945. The first is located at Lake Helena in Lewis and Clark County and the second is a 16-foot structure near Nye in Stillwater County. The Commission constructed the Nye Bridge to accommodate mining activity in the Beartooth Mountains. The bridge was the last reinforced concrete slab bridge built by the Commission until 1955.

Between 1955 and 1991, the Commission built 255 reinforced concrete slab bridges in Montana. Most are approach spans to steel girder or prestressed concrete bridges located on or adjacent to the interstate highway system. The bridges are concentrated in 77% of the Montana counties. Like the T-beam bridges, the only difference in the design between 1921 and 1991 is the replacement of the standard concrete rails with metal guardrails.

Although reinforced concrete was a durable and economical building material for engineers, it did not lend itself easily to large-scale construction projects. The bridges could not be prefabricated and, instead, required the forms for each bridge to be constructed individually. Since American bridge engineers were continually seeking new materials and construction methods, prestressed concrete was perfectly suited to the demands of the post-World War II construction boom in the United States.[20]

Prestressed Concrete Bridges

Prestressed concrete is the penultimate construction material for highway bridges. It consists of highly stressed steel cable embedded in concrete. The cable introduces compressive forces into the concrete that offsets the tensile stresses caused by the dead weight of the structure. Prestressed concrete combines the strength of steel with the durability of concrete. The material is representative of late 20th century American engineering technology. The prefabricated modules are easily manufactured and transported to the construction site. The uniform appearance of the structures, however, has caused one writer to comment that most of the bridges "have the inevitable characterless stamp of prefabrication, the component parts often

being strung together in a series of short spans resembling a train of boxcars or endless ranks of infantry." Prestressed concrete met the high standards required by the planners of the interstate highway system. Low railed, designs were favored by the highway engineers who underscored designs capable of handling heavier live loads. Prestressed concrete deck bridges were ideally suited for the interstate program.[21]

Prestressed concrete was initially developed in the United States in the 19th century. Californian P. H. Jackson experimented with steel wire reinforcement in concrete during the late 1880s in San Francisco. Because of limitations in the steel, however, his experiments were unsuccessful and he abandoned his investigations. Jackson's design was similar to Monier's system of embedding wire mesh into concrete to reinforce the material. Until the late 1920s, most reinforced concrete researchers attempted to improve reinforcing bars rather than develop any new form of the material.[22]

Although first experimented with in the United States in the early 20th century, prestressed concrete technology was later developed in Europe by Eugene Freyssinet. In 1930, he replaced standard reinforcing bars with high strength steel wire. Because of improvements in steel production, Freyssinet's experiments with the new material were successful. The outbreak of World War II in 1939, however, prevented the application of the material to bridge construction until 1946.[23]

The devastation caused by the war in Europe provided the impetus for the refinement of prestressed concrete. In western Europe, nearly all the major bridges were destroyed in the closing months of the war. Aided by the Marshall Plan, west European governments initiated a program to replace the destroyed bridges. Prestressed concrete was ideally suited to the reconstruction program. Advancements in prestressed concrete technology in the late 1940s were made primarily in Germany. Between 1945 and 1949, the Germans improved on Freyssinet's invention and used it to replace the shattered spans. While European bridge engineers were quick to embrace prestressed concrete, the more conservative American engineers were reluctant to part with traditional reinforced concrete. Until the late 1950s and the onset of the interstate highway program, bridge construction was dominated by steel girder and floor beam bridges for long span structures.[24]

Though the first prestressed concrete bridge was built in Pennsylvania in 1948, the material was not widely used in America until after the initiation of the interstate highway program in 1956. In 1955, the Bureau of Public Roads and the concrete industry published standard plans for prestressed highway structures in their *Criteria for Prestressed Concrete Bridges*. Two years later, an American Association of State Highway Officials - Prestressed Concrete Institute committee developed four standard I-sections for use in prestressed concrete bridges. The standards specified that I-sections should be able to carry their own dead weight load free in standardized spans of 30 to 100-feet.[25]

The first standardized prestressed bridge in Montana was constructed by the Department in Big Horn County in 1958 and crossed the Little Big Horn River near Crow Agency. The bridge is 155-feet long and 27.7-feet wide. The structure includes three spans--the standard for the later interstate-related bridges. By 1961, the Highway Department had built 85 prestressed concrete structures, with only 29

of the bridges associated with the interstate system. Thereafter, the number of prestressed concrete bridges grew steadily until the interstate system was largely completed in the mid-1970s. By 1991, 1,275 prestressed concrete bridges were located on Montana's interstate, primary and secondary highway system (only 41%, however, are located on or adjacent to the interstate highways).

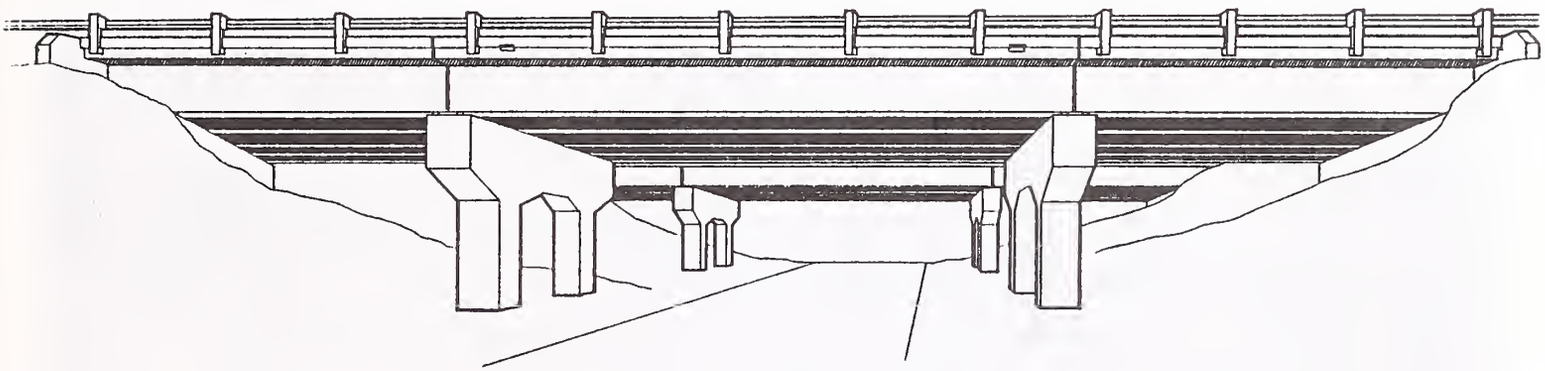


Diagram of the basic components of a prestressed concrete bridge (illustration by John Robinson).

The construction of prestressed concrete bridges boomed during the 1960s and 1970s. Between 1962 and 1973, the Highway Department built 668 prestressed concrete bridges. Over 45% of the structures are located in just ten counties (all of which are crossed by interstate highways). The structures are uniform in design and material with variations only in length and the number of spans. All the bridges average approximately 130-feet long in length. Most are three-span structures supported by reinforced concrete "hammerhead"-style bents. Although the use of prestressed concrete bridges is basically associated with the interstate program, less than half of the structures are located on or adjacent to interstate highways.

By 1959, the construction of the first interstates in the state caused a boom in prestressed concrete bridge construction that did not abate until the late 1970s. Between 1960 and 1991, 1,235 prestressed concrete bridges were constructed by the Montana Department of Highways on the state's interstates, primary and secondary

systems. Construction of prestressed spans were not limited to the interstates, although the years of the greatest number of bridges built coincide with interstate projects. From 1960 to 1970, the Department built 561 prestressed concrete bridges. Most were located on or adjacent to the interstates--particularly Interstate 90 in the vicinity of Billings and Butte and Interstate 15 near Great Falls. The Montana Department of Highways constructed 437 prestressed concrete bridges between 1971 to 1981. Located on primary and secondary roadways, most of these bridges replaced sub-standard bridges and was tied directly to the goals of the 1968 and 1971 Federal-Aid Road Acts.[26]

The underside of a prestressed concrete bridge showing the girders.

As the interstate program wound down in the 1980s, the Department constructed only 237 prestressed concrete bridges--primarily on Interstate 15 and Interstate 90. Identical in design and materials, prestressed concrete bridges mark the culmination of bridge design and standardization in Montana. It reflects the uniformity of design and materials sought by bridge engineers since the late 19th century.

Others

Rainbow Arch Bridges

In 1911, James Barney Marsh patented an arch bridge that was distinctly different from those hitherto developed in the United States. The Marsh or Rainbow Arch bridge consists of reinforced concrete arches that function in much the same capacity as a steel through truss. The concrete arches flank the roadway and are tied to the piers by steel rocker shoes. One of the shoes was "engineered to allow for expansion and contraction of the structure and roadway." Unlike the standard concrete arch bridge, rainbow arches rise above the bridge deck, allowing the driver to pass between the arches. Since the structure lacks the type of abutment common to most concrete and steel bridges, extra chords and ties were added to stiffen the bridge. Rainbow Arch bridges were built in great numbers in the Midwest and on the West Coast, but there is only one example of the type in Montana.[27]

The Morel Bridge is the only Marsh or Rainbow Arch Bridge in Montana. Built in 1912 by Montana State Prison inmates, the bridge was located on a county road. It is now surrounded by one of the Warm Springs tailings ponds (Brian Shovers).

The Morel Bridge is located on a county road near Warm Springs in Deer Lodge

County. The structure is a 90-foot, single-span bridge that originally crossed Silver Bow Creek. Soon after the completion of the Chicago, Milwaukee, St. Paul & Pacific Railroad in the area in 1909, the Deer Lodge County Commissioners decided to construct a bridge between the railroad's substation at Morel and Anaconda. In 1913, the county paid H. B. Grant to complete the design specifications for the bridge and the materials were ordered for its construction. The bridge was built by Montana State Prison inmates in 1914. With the construction of a nearby Anaconda Company tailing pond, the channel of the creek was relocated and the bridge was closed for traffic. The Morel Bridge is the only example of an historic-age rainbow arch bridge in Montana.[28]

Box Culverts

Box culverts are the earliest reinforced concrete stream crossings in Montana. Since they also functioned as bridges, the box culverts served a dual role. A box culvert was generally used where its construction would substitute for a bridge without any loss of waterway area. The box-shaped structures range in size from small single barrel (or cells) units to large multi-barrel units with either rectangular barrels or concrete pipes. Natural rock sometimes functioned as the floor for the structure. Although not true box culverts, early culverts occasionally consisted simply of a concrete slab on wing walls. The Milk River Ford box culvert in Phillips County fits this category.

There are twenty concrete box culverts located on Montana's primary and secondary roads. The earliest box culvert was constructed on a county road in Big Horn County in 1910. The Bighorn Canal Bridge was built by county construction crews and served as a headgate for an irrigation canal. The culvert consists of five barrels with the headgate apparatus located to the west of the structure. Consistent with pre-1930 box culverts, there are no guardrails flanking the structure. The design of the culvert is similar to the Conley Street Bridge in Deer Lodge.

The Commission constructed only three concrete box culverts during the Great Depression. All are located in western Montana and were built by county construction crews. Between 1940 and 1991, the Commission constructed only 15 concrete box culverts. By World War II, Commission relied increasingly on concrete and metal pipes to serve as culverts instead of the more expensive, larger and more complex box culverts.

Conclusion

Although reinforced concrete provided a durable and, sometimes, aesthetically pleasing bridge design, it was not without problems. Since engineers did not completely understand the nature of reinforced concrete until the third decade of the 20th century, the Montana Highway Commission's bridge department was without anyone specialized in its design. Consequently, they did not standardize reinforced concrete designs until about 1924. Most of the problems with reinforced concrete was not with the design, but poor construction techniques and the use of unskilled labor to mix and pour the concrete. While there have been few reinforced concrete bridge failures in Montana, one author has stated that,

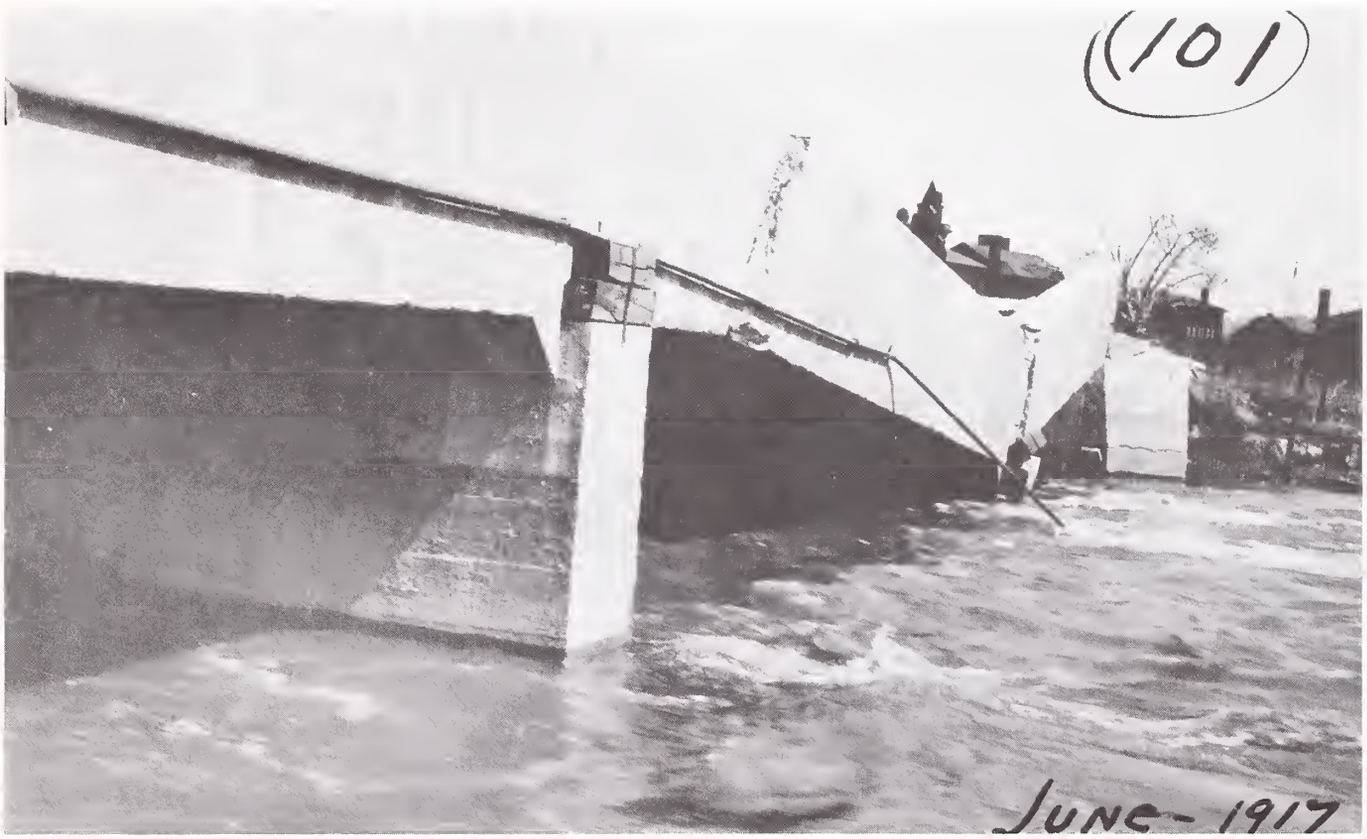
> The principal reason for [failures] is not so much due to design, but to

> workmanship, and the usual practice of putting work out to tender and accepting the lowest estimate for the work . . . . Owing to the keen competition the contractor is necessarily obliged to 'trust to chance', viz., take the work at an unreasonably low figure and rely on making up the deficiencies in his price in bad workmanship and material.

The author further declared that reinforced concrete work requires "scrupulous workmanship and almost painful accuracy" in its construction.[29]

In general, the Commission's use of reinforced concrete has been more practical than imaginative. Except for three monolithic concrete arch structures in Great Falls and Park County, Montana bridge engineers have relied on simple T-beam and slab bridges. The Commission usually built reinforced concrete bridges where they were needed. Because of the cost and need for highly skilled labor to build reinforced concrete structures, the Commission built few concrete bridges until improvements in technology made the material more accessible to bridge engineers in the late 1950s. In Montana, the high quality of the workmanship and design of reinforced concrete bridges is responsible for the longevity of the structures. While many structures were supplanted with prestressed concrete during the interstate construction projects, many more are still in use on the state's primary and secondary road system. They are reminders of a bridge technology that never gained the prominence in Montana that it held in other states until the advent of prestressed concrete.

In June, 1917, the reinforced concrete slab bridge over the Boulder River south of Boulder failed during spring run-off. The river undercut one of the piers causing the bridge to settle into the water (Montana Historical Society).



Another view of the failed pier on the Boulder River Bridge in 1917 (Montana Historical Society).

Jefferson County funded the construction of a new two-span reinforced concrete T-beam bridge in the fall of 1917. The bridge was located on Montana Highway 69 on the southern outskirts of Boulder. This photograph shows the concrete mixing plant. The Boulder School and Hospital is located in the background (Montana Historical Society).

This photograph shows the bridge with frame for the concrete forms still in place. The mixing plant is on the left. The bridge was structurally similar to the Conley Street Bridge in Deer Lodge (Montana Historical Society).

Photograph of the aggregate source adjacent to the bridge on the Boulder River (Montana Historical Society).

Pouring the concrete into the forms. This method was used until at least World War II (Montana Historical Society).

The completed bridge after the forms had been removed. The forms underneath the bridge were left in place until the concrete had cured (Montana Historical Society).

Part 6 - Miscellaneous

Suspension Bridges

There is only one vehicular suspension bridge located in Montana. The Pugsley Bridge crosses the Marias River southwest of Chester in Liberty County. It is a three-span 329-foot structure resting on concrete piers and abutments. The cables are anchored to two steel towers strengthened with cross trusses. The bridge is essentially a timber deck structure with the suspension cables providing extra structural support (timber bridges are not usually this long). The bridge was built in 1951 by R. T. Hurdle & Sons of Billings and includes a unique braced chain-type suspension system.

The Pugsley Bridge in Liberty County is the only suspension bridge in Montana and the only one of this type in the country.

Boxcar Bridges

The intent of the Montana Highway Commission's bridge department has been to construct bridges as economically and expeditiously as possible. The bridges are

designed to meet many particular traffic and weight requirements in order to provide safe barrier crossings .for the public. The Commission has met their goals with the development of timber, truss, steel girder and reinforced concrete bridge designs. In small communities and on private property, however, economic constraints have led tax-payers and land owners to seek alternate methods to cross small obstacles.

In Montana, one of the most popular methods is the use of railroad boxcars. Most boxcars consist of 40 x 10-foot wood frames with floors strengthened by steel beams. Once the walls and roof have been removed, the floors make ideal bridges for small crossings. Since the bridges are, for the most part, located on private roads, they are not required to meet state or federal bridge standards. Consequently, it is not known how many "boxcar" bridges exist in Montana.

The Fourth Street Bridge in Bearcreek consists of a steel gondola railcar. It was placed on top of the remains of the timber bridge that has been located on site since at least 1914.

Ferries

In addition to river and stream fords, one of the earliest forms of barrier crossings in Montana were ferries. During the 19th century, ferries usually consisted of a flat-bottom boat, open at each end, and guided across the river by a tow cable. The

early ferries were powered by horses or mules located on each bank or by hand winches located on the craft. By 1920, the boats were propelled by gasoline engines. Three river ferries are still in operation in Montana--at Virgelle (Coal Banks Landing), Carter and north of Winifred. All are located on isolated state secondary or county roads on the Missouri River between Great Falls and the Fred Robinson Bridge in Phillips and Fergus counties.

Yellowstone River ferry at Columbus, 1885 (Montana Historical Society).

Although the roads leading to the ferry landings are state or county-maintained, the ferries are operated by private individuals who contract with the counties in which they are located. The ferries are funded by the state gasoline tax and the operators are paid by the counties. To remain in business, the ferry operators must meet minimum state safety requirements (the Coast Guard inspects the boats annually). The ferries are seasonal operations and open from April to about mid-October--depending on ice conditions on the Missouri River.

In 1864, the first Territorial Legislature granted franchises to five companies to operate and maintain ferries in the territory. Although bridges had replaced many of the ferries by 1866, the Legislature chartered an additional eighteen ferry companies--located on the Missouri, Sun, Big Horn Missoula and Yellowstone rivers. The

1867 and 1869 territorial legislatures revoked six of the charters, but allowed two ferries to remain in business. The Legislature, moreover, chartered an additional four ferry companies. Between 1872 and 1900, the Legislature did not charter any companies, instead turning their operation over to the counties. The counties, in turn, licensed most of the companies until they could begin construction of permanent bridges.[1]

Missouri River ferry at Carter, 1993.

Although there were few ferries in operation in Montana by 1913, the Montana Highway Commission quickly developed plans for them. The Virgelle ferry was the first Commission-administered boat. Sometime between 1913 and 1917, the Montana Highway Commission standardized ferry boat design. The standard ferry was a 52-foot long flat-bottomed boat with a draft of approximately 12-18-inches. The boats were powered by 25 horsepower International-Harvester tractor engines (many still have the same type of engine). As with bridges, the Commission modified the boats to accommodate changes in vehicular weights and size. The isolated Montana ferries are the last remnants of an old transportation system and have changed little since they were constructed by the Commission in the first quarter of the 20th century.[2]

PART 7 - CONCLUSION

Bridges are the most prominent features on Montana's transportation landscape. They both interact with and stand apart from the road systems and are its most sophisticated components. The history of bridge engineering in the United States is marked by experimentation with forms and materials. As technology improved, the science of bridge engineering was marked by "continual replacement of one material being superseded by a better one, of one bridge yielding its site to a new and stronger one." Although new bridges continually replace the old, there are still large numbers of their predecessors on the Montana road system. These symbols of the past are graphic reminders of the system's origins and evolution.[1]

Historically, Montana bridge builders and engineers have not been particularly innovative in their use of building materials and were conservative in their designs. Although there are a few exceptions (i.e. the Fromberg Bridge, Pugsley Bridge and Natural Pier Bridge), Montana's bridges are standard designs developed to facilitate the socio-economic and transportation development of a given area. Eventually, many of the bridges were abandoned for engineering and economic reasons.

There are examples of nearly every major type of bridge on Montana's road system. They are ideally suited to the demands placed on them by their users. Because of the great size of the state and the limited funding available to construct roads and bridges, Montana engineers had to make the best of the material and money available to them. Consequently, there are large numbers of timber and simple steel girder bridges and a relatively few truss and reinforced concrete structures. Until the invention of prestressed concrete--a cheap and durable material--no large permanent bridge construction program was possible in Montana (state bridge engineers built timber bridges as temporary solutions to the road expansion program).[2]

In Montana, older bridges co-exist with the new structures and provide a very visible record of the history of bridge construction in the state. One author has commented that bridges "serve not only as gauges of technological advancement in design and construction, but as singular indicators of the tenets, values and ambitions of the people who erected them."[3]

PART 8: THE BRIDGES

The Scanland Toll Bridge

Located close to the Bozeman Trail ford, the Madison Bridge Company built the bridge in 1867. The legislature chartered the company in 1866 and again in 1867. The territory authorized Milton and Robert Canady to operate the bridge until 1875. An 1871 photograph of the toll bridge shows an eight-span timber bridge with log crib piers and king-post and queen-post trusses (the foundation of two of the piers is still visible in the river at the site). The brothers sold the bridge to Paul Hayward, a pioneer Madison County miner in 1875. He, in turn, sold the structure to John Scanland for $1800 in 1876. Between 1884 and 1889, the bridge fell into disrepair. Local residents, however, continued to use the crossing until the county built a steel truss bridge 1½ miles upstream in 1890.[1]

The Scanland Toll Bridge on the Madison River, Circa 1871. (W. H. Jackson Collection, Museum of the Rockies).

The Fort Benton Bridge

The first major bridge company project in Montana was the Fort Benton Bridge. The completion of the Northern Pacific Railroad in 1883 contributed to a sharp decline in the river-based commerce of Fort Benton. In an effort to draw trade from the prosperous Judith Basin area, a cartel of Fort Benton businessmen formed the Benton Bridge Company in 1887. The group sought to fund construction of a bridge across the Missouri River and provide access to the Montana Central Railroad. The company hired the Milwaukee Bridge and Iron Works to build the bridge. Since the river was classified as navigable at Fort Benton, the three-span bridge was built with a swing span to allow steamboat traffic on the river (the span was used only once--in 1908). The span was one of the first vehicular bridge to cross the Missouri River in Montana and was the first all-iron steel truss structure in the state.[2]

The swing span of the Fort Benton Bridge was used only once--in 1908, long after the steamboat era on the Missouri River had passed. The span was replaced with a pin-connected Parker truss by the Boomer & Blakeslee company in 1925. (Fort Benton Historical Society).

The Natural Pier Bridge

Although the Natural Pier Bridge includes one of the more unusual design features found on a bridge, the history of its construction is typical of many structures built in Montana during the late 1910s. Located on Old Highway 10 in Mineral County near Alberton, the center pier rests on a rocky outcrop in the Clark Fork River. The 374-foot single-lane bridge has three riveted Warren through truss main spans, with timber approach spans and concrete abutments. The trusses incorporate riveted plate girders.[3]

The Natural Pier Bridge in Mineral County.

Promoters carved Mineral County from Missoula County in 1914. Because of pressure from mining and lumber companies and the Yellowstone Trail Foundation, the new county embarked on an ambitious bridge construction program in 1916. The Natural Pier Bridge was one of three bridges built in the county before 1919. Although the county took full responsibility for the construction of the bridge, financial limitations and the proposed bridge's location forced the commissioners to seek aid from the US Department of Agriculture.[4]

Mineral County's confusion about whether it could legally enter into a contract with

a federal agency to build a bridge in a forest reserve delayed the initiation of the project. Wausau Iron Works company of Wausau, Wisconsin was the low bidder for the construction of the bridge. The company's Montana agent, John O. Fischer was the firm's foreman for the construction project. By May 1, 1917, county engineer Ray Leib reported that his crews had completed work on the bridge's approaches and had driven 40 pilings. Leib oversaw the undertaking for Mineral County until the county commissioners replaced him in June.[5]

Work on the bridge progressed steadily until late June, when the Mineral County Commissioners halted construction because of a financial shortfall. Montana Highway Commission member A. W. Mahon and District Engineer G. H. Lantz along with the county commissioners requested an additional $14,000 from the county's constituents and the Department of Agriculture to finish the project. Although the USDA was able to procure the necessary funds for the bridge, the amount of money needed to complete the project required a special bond election to raise the necessary revenue. Because of county law, however, the special election could not be held until October, 1917. Wausau Iron Works and the county ceased construction on the bridge until the bond election could be held. Consequently, the the bridge was not finished until 1918. When completed, the bridge cost nearly $100,000 and was known as the "scenic bridge" to local residents.[6]

The Fred Robinson Bridge

The Fred Robinson Bridge is one of only two Missouri River bridges located between Fort Benton and Fort Peck Dam--a distance of approximately 250 miles. Phillips and Fergus county businessmen and farmers began lobbying the Legislature for a bridge in 1920. Their efforts for a bridge gained sufficient political support in 1929 when the Montana Legislature requested proposals from the Highway Commission. The Commission selected four possible sites for the bridge and hired Ira H. Slawson of Banks, North Dakota to core drill at each site. The 1930 Commission report narrowed the site for the bridge to two locations: the Power Plant Site (at the current location of the McClelland Ferry north of Hilger) and the Rocky Point Site northeast of Roy. All bridge plans developed by the Commission for the bridge were variations of the Camelback Parker through truss.[7]

The Commission recommended that the bridge be built at the Rocky Point site on the border of Phillips and Fergus counties. The Commission chose the location because of optimum foundation conditions and a lower cost for the construction of approach roads (about 141 miles in all). The bridge department estimated that the bridge would cost about $325,000 with a total cost for the project (including the approach roads) of $1,345,000. Because of the Fort Peck Dam construction project and the Commission's emphasis on smaller timber and girder bridges, state support for the proposed Missouri River bridge languished until after World War II.[8]

After 1945, Fergus and Phillips counties renewed their support for the construction of the bridge. The counties' Chambers of Commerce and eastern Montana newspaper circulated appeals that described the economic and social benefits of the bridge. Phillips County state senator Fred Robinson, meanwhile, actively lobbied for the structure in the legislature. As a result, the legislature again requested the Commission develop plans for the bridge. The through truss design was dropped by

bridge designers in favor of a steel girder design. Because the construction site was located within the Charles M. Russell National Wildlife Refuge, the Commission was able to build the Fred Robinson Bridge almost entirely with federal funds rather than operate it as a toll facility.[9]

The Commission let the bridge to contract in 1955. Built by the N. A. Nelson Construction Company of Sheridan, Wyoming, the steel girder and floor beam structure consists of four main spans and two concrete T-beam approach spans. The bridge is 698-feet long and 31.8-feet wide with two 14-foot driving lanes. The bridge rests on three reinforced concrete piers. Dedicated by Fred Robinson and Montana Governor Hugo Aronson on August 16, 1959, the bridge marked the culmination of a nearly 40-year struggle by local citizens to provide an access between the isolated northcentral and southcentral agricultural areas of Montana.[10]

The Fred Robinson Bridge is a steel girder and floor beam bridge built between 1955 and 1959.

The Cottonwood Creek Bridge

The Cottonwood Creek Bridge is located approximately 15 miles southwest of Miles City. Cottonwood Creek is an intermittent stream in a largely stockgrowing area.

The bridge consists of a single 25-foot span resting on earthen approaches and abutments. The abutments are supported by wood backwalls braced with pilings (common to Montana timber bridges). The bridge has the standard twelve lines of 4" x 16" treated timber stringers and a two-rail wood guardrail. It has a wood deck with a gravel overlay.

The Cottonwood Creek Bridge is one of only three timber bridges remaining in Montana constructed by the Commission's bridge department in 1928. Built by an unknown contractor from bridge department designs, the structure was included as part of a federal plan to provide rural ranchers with easier access to railroad shipping points.

Cottonwood Creek Bridge. The bridge is typical of timber bridges built in the rural areas of Montana during the 1920s and 1930s.

Buckingham Coulee Bridge

Located about three miles southwest of Hysham in Treasure County on Montana Highway 311, this four span bridge crosses a dry coulee in a wheat and sugar beet production area. The bridge is supported by treated timber trestle pile bents with cross-trusses and sway braces. The pile bents are set directly into the coulee bed and have no concrete footings. The bents are held in place by friction from the weight of the superstructure. The bridge has wood abutments and earth approaches supported by wood backwalls braced with wood pilings. The abutments are shored with sandstone rip rap to prevent erosion. The bridge superstructure has the standard treated wood stringers and decking material. The wood deck has a plant mix overlay and the two-rail guardrail is intact. The contractors rechanneled the

creek bed to prevent erosional damage to the structure during construction.

Designed by the Montana Highway Commission, the Buckingham Coulee Bridge was built in 1936. It was one of 70 timber bridges built in Montana that year and one of two constructed in Treasure County. The bridge was fabricated by the C. R. McCormick Lumber Company of Portland, Oregon. The company fabricated approximately 19 bridges located in Montana during the late 1930s. The Collison & Dolven Company of Billings built the bridge. Frederick Collison (who was employed as Superintendent of Construction for the Security Bridge Company until 1925) and Noel Dolven operated a road contracting firm in Billings from about 1932 until the mid-1940s. The company built two other bridges in Montana in the 1930s. The Department of Defense listed the Buckingham Coulee Bridge as a component of the National Defense Highway Network in 1950.[11]

Buckingham Coulee Bridge. Built in 1936 by the Collison & Dolven Company of Billings.

The Dodson South Canal Bridge

The Dodson South Canal Bridge is located on U.S. Highway 191 on the southern outskirts of Malta in Phillips County. The bridge consists of four 25-foot spans supported by three trestle-type pile bents sheathed with laminated wood strips to prevent scour to the bents. The pile bents have concrete footings. The bridge's superstructure has the standard twelve treated timber stringers (one is clamped) and wood backwalls with piling braces. The wood deck has a plant mix overlay and is flanked by the usual two-rail wood guardrails. An unusual feature of the bridge is the wood sidewalk attached to the east side of the structure (it was not added to the

structure until 1965). The bridge rests on wood abutments with earth approaches. The sidewalk has wood posts with a two-rail wood guardrail and a wood deck.

Built in 1938, the Dodson South Canal Bridge was designed by the Montana Highway Commission's bridge department and serves a largely wheat farming area. The Dodson South Canal was built by the Bureau of Reclamation in 1910 and carries water to Dodson, Wagner, Malta, Bowdoin and beyond. The structure was one of 78 timber bridges constructed in Montana in 1938. It was fabricated by the National Pole and Treatment Company plant in Spokane, Washington (the company fabricated 49 bridges in Montana during the 1930s). Built by Nolan Brothers of Minneapolis, Minnesota, the bridge was one of three constructed by that firm in Phillips County in 1938.[12]

Dodson South Canal Bridge in Malta. Note the sidewalk, laminated wood sheathing that protects the pile bents.

Snowden Bridge

The Snowden Bridge was built for the Great Northern Railroad by the American Bridge Company in 1913 and crosses the Yellowstone River near the North Dakota border. The only vertical lift bridge in the state, the Snowden Bridge was designed by J. A. L. Waddell and consists of three 275-foot fixed spans and 296-foot lift span. When completed, it was the longest vertical lift bridge in the world.[13]

In 1925, the Great Northern and the Montana Highway Commission modified the bridge to accommodate vehicular traffic. Because the bridge was the only

Yellowstone River crossing in the area, the railroad charged vehicles tolls to cross the bridge. The railroad charged 50¢ per car and 15¢ for each passenger. A toll keeper was stationed at the bridge to regulate traffic and to operate the system of signals to prevent any accidents from occurring. The Snowden Bridge continues to convey railroad traffic over the river in this area.[14]

The Snowden Bridge.

Orange Street Bridge

Originally known as the Harris Bridge, the structure was built by the Portland Bridge Company for the Federal government and crosses the Clark Fork River in Missoula. Work on the bridge was initiated in July, 1936 and completed a year later. The 503-foot bridge cost $169,000 and facilitated traffic on U.S. Highway 93. Local resident Edna Tingley won a contest sponsored by the Missoula Active Club to name the bridge. She christened it the "Parkway Bridge" at dedication ceremonies held on July 16, 1937.[15]

The reinforced concrete piers were built by the Portland-based company during the winter of 1936-37. During that phase of the work, one bridgeman later recalled that

work on the piers was "laborious and meticulous" since the cement was mixed at the site. He added that,

> . . . Wheelbarrows were loaded up with a hand shovel and, filled with powder, weighed on a platform scale. The cement mix was dumped into the hopper, churned for exactly three minutes, dumped into cement buckets, then lifted by crane to the work site.

The day the bridge opened, over 200 automobiles used the bridge. Today, over 16,000 vehicles cross the bridge each day.[16]

The Orange Street or Parkway Bridge in Missoula. The bridge is one of the more visible deck truss bridges in Montana.

Locate Creek Bridge

The oldest known steel stringer bridge in Montana is situated on Locate Creek in Custer County. Built in 1901, the bridge is 40-feet long and 16-feet wide. The structure rests on earth abutments with wood back and wing walls supported by timber pilings. Small steel I-beams have been riveted together to create

guardrails for the structure. The Locate Creek Bridge was one of ten steel girder bridges constructed by Custer County between 1901 and 1912. The structures are all located on farm-to-market roads and were built to provide access to Miles City for homesteaders. The design of the bridge is nearly identical with the other steel girder bridges built in the county during the first decade of the 20th century.

Constructed in 1901, the Locate Creek Bridge is the oldest known steel stringer bridge in the state.

Emigrant Creek Bridge

At first glance, the Emigrant Creek Bridge in Park County appears to be a reinforced concrete T-beam structure. Structurally, the bridge is identical to a T-beam bridge, except that steel I-beam girders function as the T-beams. The girders support a reinforced concrete slab and concrete guardrails with semi-elliptical openings and indented concrete endposts. The abutments, back walls and wing walls are reinforced concrete and similar to those associated with reinforced concrete slab bridges. Built by an unknown contractor in 1928, the bridge is located on Montana Secondary 540 north of Pray. The single-span structure is 33-feet long and 23-feet wide.

The Emigrant Creek Bridge, built in 1928.

The bridge is representative of the girder design in Montana during the 1920s and 1930s. Because of their simplicity, the Bridge Department often designed girder bridges with features similar to those associated with timber or reinforced concrete bridges. In the case of the Emigrant Creek Bridge, it is essentially a concrete T-beam bridge with girders instead of concrete beams. In most cases, steel girder bridges are structurally similar to reinforced concrete T-beam bridges. During the 1920s and 1930s, bridge designers embellished the basic girder bridge with features analogous to reinforced concrete and timber structures.

Northern Pacific Railroad Overpass

Like the Emigrant Creek Bridge in Park County, the Northern Pacific Railroad Overpass east of Garrison is essentially a reinforced concrete T-beam bridge with steel girders. The bridge was built by the Dakota Concrete Company, Inc. of Minot, North Dakota between June and mid-September, 1931. Work was temporarily halted on the structure when railroad officials complained that the contractor had nearly severed the company's telegraph wires. Because of the bridge's location in a rock declivity, the Commission hired a contractor to blast away the overhanging

rock. In the process, the company caused extensive damage to the southwest abutment and deck of the new bridge. The contractor repaired the bridge by mid-1932.

Northern Pacific Overpass Bridge near Garrison in Powell County.

The structure consists of three spans and is 117-feet long and 24-feet wide. The skew bridge rests on two hammerhead-style concrete bents and carries old U.S. Highway 12 over the railroad grade (this segment of the roadway was abandoned in 1981). The concrete deck is flanked by two reinforced concrete guardrails that are structurally similar to those found on Commission concrete bridges built at approximately the same time.

This bridge was funded by the $6 million emergency debenture enacted by the state legislature and by the Northern Pacific Railroad. The railroad provided approximately 43% of the $10,325 cost of the structure. The bridge combines the structural elements of steel girders with reinforced concrete bridges.[17]

Great Northern Railway Overpass

During the first years of the New Deal, bridge builders built 58 small steel stringer bridges on farm-to-market roads. By the late 1930s, however, the program funded construction of more massive girder structures to provide grade separations at railroad crossings. The Great Northern Overpass in Shelby was one of those projects.

Built in 1938, the structure is 335-feet long and consists of five spans supported by four open concrete column bents and two concrete tower piers decorated with an Art Deco motif. The weight of the structure caused the collapse of an underlying water main during in the winter of 1939. The entire structure settled more than was specified in the design plans and the bridge had to be strengthened and straightened with hydraulic jacks. Because of financial commitments and the Second World War, however, the bridge was not repaired until 1945. Flanked by reinforced guardrails, the deck is about 33-feet wide.[18]

The Great Northern Raiload Overpass in Shelby. The structure is typical of many railroad overpasses constructed in Montana during the 1930s. The Commission constructed many overpasses to seperate grade crossings for tracks and roads in an effort to reduce the number of railroad-related accidents.

Orange Street Underpass

The last major structure built by the Commission in the 1930s was the Orange Street Underpass in Missoula. Constructed in 1939, the structure is a combination steel stringer and reinforced concrete structure. It was constructed by the Commission and the Northern Pacific Railroad to provide unobstructed passage for traffic on the roadway. The structure is 34-feet long and the underpass accommodates two-lanes of traffic. The roadway is flanked by two walkways with arched openings on the arcade and metal guardrails. The fascia of the buttressed structure is reinforced concrete. Brick warehouses associated with the railroad are located on top of the structure and predate the construction of the overpass.

The Orange Street Underpass, circa 1939 (Montana Historical Society).

The O. S. Warden Bridge in Great Falls

The 2,093-foot O. S. Warden Bridge was built in 1951 by Anderson Construction Company of Great Falls. The Missouri River bridge consists of six steel girder and floor beam spans and 21 steel stringer approach spans (the S. Birch & Sons and the HGR Construction companies of Great Falls built the approaches). The structure is

30-feet wide with two 14-foot driving lanes and is flanked by reinforced concrete railings. The bridge was named for Oliver S. Warden, a Great Falls newspaperman, entrepreneur and one of the first members of the Montana Highway Commission. When completed, the bridge cost $1,640,474 and was the longest bridge in the state. It allowed the commercial development of the area in Great Falls by permitting direct vehicular access to the Tenth Avenue South from U.S. Highway 91 and, later, Interstate 15.[19]

Governor John Bonner, the Great Falls Chamber of Commerce and the Montana Highway Commission dedicated the bridge during the city's Fall Festival on September 15, 1951. The Chamber of Commerce president praised Warden and his dedication to the state,

> And here we have it . . . a lasting monument to the loyalty and vision of community leaders with a burning desire to serve their fellowmen. Here we have the longest bridge, in the largest city in the state, dedicated to the memory of men whom we never shall forget.[20]

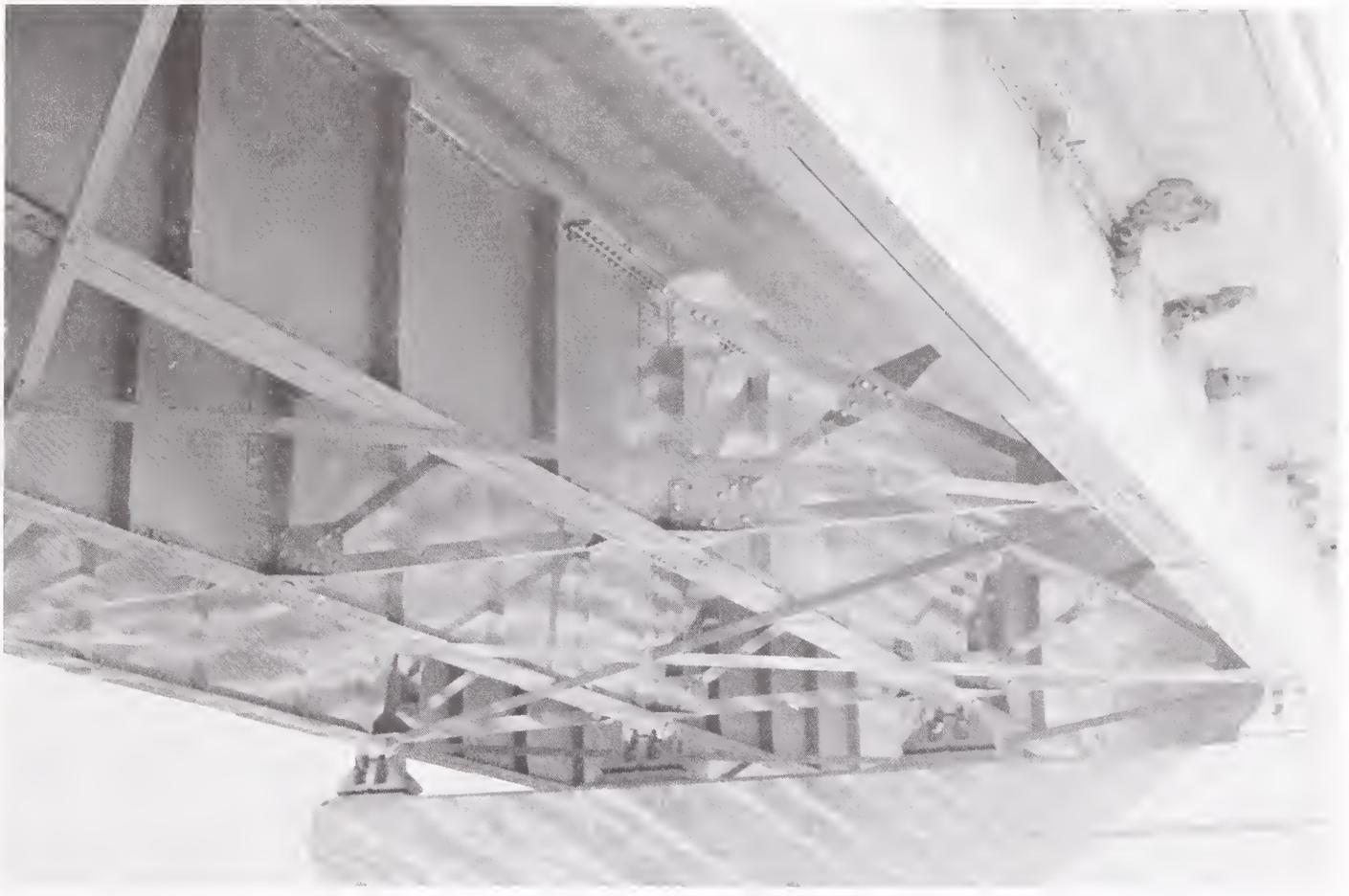
At the time of its construction in 1951, the O. S. Warden Bridge in Great Falls was the longest bridge in Montana (it was surpassed by the new Yellowstone River Bridge in Billings in 1992). Built by the Anderson Construction Company, the Warden Bridge consists of 21 approach spans and six main spans.

Clark's Fork of the Yellowstone River Bridge at Belfry

The Clark's Fork of the Yellowstone River Bridge is located approximately one mile north of Belfry on Montana Highway 72. The three-span bridge is 249-feet long and 27.7-feet wide, It rests on two concrete piers with reinforced concrete guardrails flanking the deck. There are 62 floor beams supported by six I-beam girders and treated timber stringers with metal stiffeners adjacent to the girders.

Fabricated by the American Bridge Company, Jerome Boespflug of Miles City constructed the bridge in 1939. He was an active bridge builder in Montana between 1914 and 1948. The Belfry bridge was one of two steel girder bridges constructed by Boespflug during the 1930s (the other is located in Havre). The Paper Calmenson Company of St. Paul, Minnesota provided the reinforcing steel for the concrete piers, abutments and guardrails.

Clark's Fork of the Yellowstone River Bridge north of Belfry. The structure was fabricated by the American Bridge Company and built by Miles City contractor Jerome Boespflug in 1939.



Detail of the underside of the Clark's Fork River Bridge. The structural design is typical of steel girder and floor beam bridges in Montana.

The Fromberg Bridge

Constructed in 1914, the Fromberg Bridge in Carbon County is a simple barrel arched structure. The bridge was financed by the county with donations garnered from local businessmen. The three span structure is 219-feet long with three 56-foot parabolic arches supported by concrete abutments and piers resting on wood piles. The bridge is 18-feet wide with a single 15'4" driving lane. The simple parabolic arches are representative of technological innovations developed during the first decade of the 20th century; they are more capable of withstanding live loads than the classic Roman arch. Ornamentation on the bridge includes cornices, indentations on the railings and granite caps on the piers.[21]

The Fromberg bridge replaced a wooden Howe through truss bridge constructed at the site in 1909 (page 45). The new bridge was built by the Livingston-based Beley Construction Company with cement provided by Gibson Concrete Works of Fromberg (coincidentally, the president of the company, John Gibson, was the County Surveyor's brother). The $11,000 contract included the demolition of the

1909 bridge. Beley Construction initiated work on the concrete bridge in late July, 1914. Although the company stated that the bridge would be completed in time for the sugar beet harvest in October, it did not open until early December. The *Fromberg Herald* boasted that "[t]he bridge will be a monument to Carbon County and the present board of County Commissioners, in that it is a permanent improvement and an emblem of progress . . . ." The newspaper also applauded the efforts of local entrepreneurs to help finance the bridge's construction with " . . . a degree of pride in the knowledge that they have helped bring to Fromberg the largest concrete bridge in the treasure state."[22]

The Fromberg Bridge was the first large reinforced concrete bridge constructed in Montana.

Chicago, Milwaukee, St. Paul & Pacific Overpass

The Chicago, Milwaukee, St. Paul & Pacific Railroad (CMSTP&P) Overpass on 25th Street North in Great Falls was constructed by the railroad in 1914. A single-span, parabolic arch structure, the bridge is 68-feet long and 42-feet wide with decorative indentations on the spandrel walls and corniced abutments. It was built to carry vehicular traffic over the railroad tracks. Since the tracks crossed an already existing roadway, the railroad was obligated to pay for the bridge's construction.[9]

The CMSTP&P Railroad Overpass in Great Falls was one of several road-related reinforced concrete structures built by the company during its early years in the state.

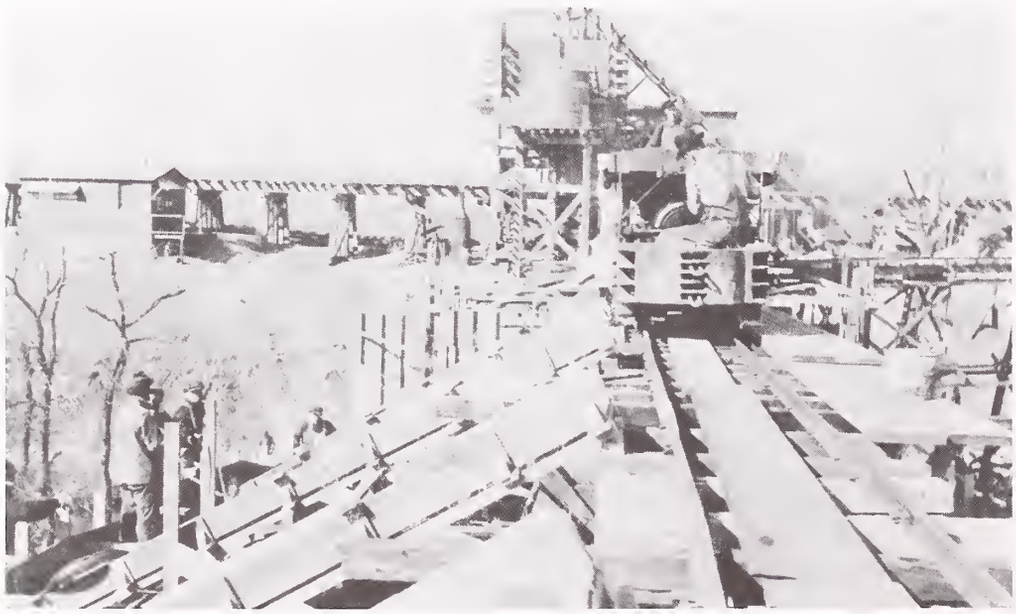
Tenth Street Bridge in Great Falls

Realizing the need for permanent Missouri River crossings in Great Falls, the Montana Highway Commission's bridge department and the Great Falls city commissioners hired Ralph Adams of Spokane and George H. Shanley of Great Falls to design both the First Avenue North and Tenth Street bridges. Essentially Kahn trussed bar system structures, the bridges were the longest reinforced concrete structures located on the state's highway system until the 1960s (the First Avenue North bridge was demolished in 1980).[23]

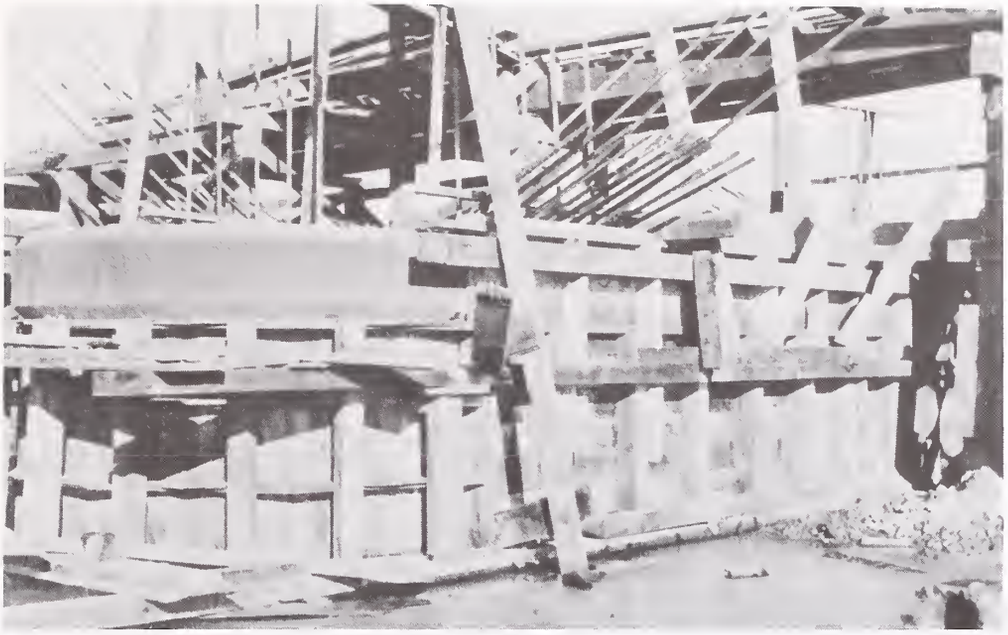
The Tenth Street Bridge was constructed in 1920 by Porter Brothers working under the supervision of bridge department engineer Evarts H. "Blake" Blakeslee. Since the bridge was also designed to carry Great Falls Street Railway company trolleys, the Montana Power Company paid approximately one-quarter of the $223,000 construction cost of the bridge. The Montana Highway Commission claimed in its 1919-1920 biennial report that the Tenth Street Bridge "represent[ed], in every detail, [the] most advanced ideas of modern bridge building."[24]

The concrete mixing plant on the north bank of the Missouri River in 1920. The ribbed arches have been completed and the deck--is about to be installed (all photographs of the construction of the Tenth Street Bridge were provided by Robert Blakeslee Photograph).

The contractors built a railroad trestle across the Missouri River to carry the concrete to the site. A concrete mixing plant, located on the north bank of the river, mixed approximately 11,000 barrels of cement with 8,500 cubic yards of gravel and sand. The contractors used 350 tons of reinforcing steel for the bridge. The construction crews utilized railcars to carry the building material to the wood forms. Porter Brothers employed approximately 40 to 100 men on the bridge until it was completed in late 1920.[25]



The concrete mixer and tram car.



One of the bridge's cofferdams.

Robert Blakeslee standing next to one of the Tenth Street Bridge's arches. His father, Evarts, supervised construction of the structure.

The partially completed bridge in 1920.

The Tenth Street Bridge in 1993.

When finished, the Tenth Street Bridge was 1,130-feet long with eight double-ribbed open spandrel arches resting on seven concrete piers. The 29' 6" wide roadway is supported by concrete T-beams. A 7'6" sidewalk is located adjacent to the roadway on the west; it is supported by reinforced concrete corbels. The Tenth Street Bridge was the largest reinforced concrete structure in Montana. The *Great Falls Tribune* described the bridge as "an imposing structure of sweeping arches, mighty abutments [and] giant girders . . . a carved monument rising above the water." The bridge was completed shortly before the third and last multi-span concrete arch bridge in Montana was finished--the Carter Bridge in Park County.[26]

The Kiowa Bridge.

The Kiowa Junction Bridge

The South Fork of the Milk River Bridge is 22-feet long and 24.3-feet wide. The Commission designed the bridge for the standard H-15 loading. The bridge is structurally identical to a bridge located on the South Fork of Cut Bank Creek--ten miles south of this bridge. The structure is stone veneered with rough-faced granite set in a random pattern. The Pacific Coast Steel Corporation of Seattle, fabricated the reinforcement steel for both bridges. Although the Montana Highway Commission did not construct another concrete arch bridge bridge until 1945, the

Forest and National Park service constructed many during the 1930s. Rock-faced concrete arch bridges are located at St. Mary's Lake, the Going-to-the-Sun Highway and on the road leading to the Lewis and Clark Caverns.[27]

The Kiowa Bridge. Built by Evarts Blakeslee in 1928, the photograph shows the bridge prior to the construction of the deck (photograph courtesy of Robert Blakeslee).

Northern Pacific Railroad Overpass near Logan

Constructed by Butte contractor Charles Goddard in 1934, the Northern Pacific Overpass west of Logan in Gallatin County is located on Montana Secondary 205 (old US Highway 10). It is an eight-span structure consisting of two triangular tower spans and six reinforced concrete T-beam spans. Because the bridge approaches the railroad crossing at an angle, it is skewed 68°23'. The concrete bents are typical of those associated with skew bridges during the 1930s.

The 345-foot bridge accommodates a 22-foot wide roadway, which was narrower than the 24-foot Commission standard. The Paper Calmenson Company of St. Paul, Minnesota manufactured the reinforcing steel; it was one of two bridges fabricated by the company in Gallatin County and was one of two T-beam bridges constructed in the area by Goddard in 1934. The overpass is the longest pre-1956 T-beam bridge in Montana.[29]

Northern Pacific Overpass, built in 1934.

Big Sheep Creek Bridge

The Big Sheep Creek Bridge in Beaverhead County southwest of Dell is a typical example of the standard Montana Highway Commission-designed reinforced concrete slab bridge. Located on old U.S. Highway 91 (now a Beaverhead County road), B. N. Crenshaw constructed the bridge in 1931. The single-span structure is 22-feet long and just over 24-feet wide. Unlike most concrete slab bridges, the structure has curved baluster guardrails flanking the deck. The guardrail on the west is concrete with a metal railing, while the eastside of the structure has the standard concrete guardrail. Based in Livingston, Crenshaw's firm constructed two slab bridges in Beaverhead County in 1931. The Colorado Builders Supply Company fabricated both bridges.

The Big Sheep Creek Bridge near Dell is typical of standard reinforced concrete slab bridges designed by the Montana Highway Commission during the 1920s and 1930s.

The Novak Creek Bridge

Constructed by the McGuire and Blakeslee Company in 1931, the Novak Creek Bridge in Cascade County is 44-feet long and 25-feet wide. Located on old US Highway 91, the two-span structure is supported by an open concrete bent. The 24-foot roadway width was standard to bridges in the 1920s and 1930s. It was one of two bridges the company built in Cascade County in 1931. Reinforcing steel for the bridge was provided by the Pueblo-based Colorado Fuel & Iron Company.[21]

The Novak Creek Bridge was one of several reinforced concrete bridges built by the Commission at the outset of the Great Depression.

Mud Creek Bridge

A typical concrete slab bridge is the Mud Creek Bridge near Ronan. Constructed in 1921, the bridge was located on U.S. Highway 93 until the Montana Department of Highways realigned the roadway in 1971. The single-span bridge is 22-feet long and nearly 24-feet wide. It is flanked by low open concrete guardrails with corniced railends. The structure rests on concrete wing walls. The structure was widened to its current dimensions in 1933. It is not known who constructed the bridge or fabricated the reinforcing steel.

The Mud Creek Bridge was constructed shortly after the Bridge Bureau developed plans for the design.

Milk River Ford

During the 1920s, two concrete box culverts were constructed on secondary roads in the state. While the Milk River Ford structure is classified by the Montana Department of Transportation's Bridge Bureau as a box culvert, it is, in fact, a primitive slab bridge. Many of its features, however, suggest a box culvert. Constructed in 1928 by Phillips County construction crews, the structure is located on Montana Secondary 243 fifteen miles northwest of Saco. The structure is 147-feet long and only 15-feet wide. It consists of a series of narrow concrete slabs resting on three barrels and seven 24-inch concrete pipes. The approaches are earth and the roadway leading to the box culvert is gravel surfaced. There are no guardrails. Signs posted at each end of the bridge state "Danger Low Bridge, Do Not Cross When Water is Flowing Over the Bridge."

The Milk River Ford Box Culvert is one earliest remaining structures of this type in Montana. It is typical of pre-Commission box culvert design (Illustration by John Robinson).

Appendix 1: Timber Bridges on or eligible for the National Register of Historic Places

Bridge	DOC	County
Morrelli Bridge	1881	Lewis and Calrk
Cottonwood Creek	1928	Custer
Drainage	1929	Teton
Drainage	1929	Teton
Jones Coulee	1929	Teton
Flat Creek	1931	Lewis and Clark
Stock Pass	1931	Lewis and Clark
Dry Coulee Stock Pass	1931	Lewis and Clark
Stock Pass	1931	Lewis and Clark
Dry Creek	1931	Lewis and Clark
Heppler Coulee	1934	Cascade
Cottonwood Creek	1934	Fallon
Simms Creek	1934	Cascade
Buckingham Coulee	1936	Treasure
Circle Diamond Coulee	1936	Phillips
Assiniboine Creek	1936	Phillips
Rye Creek	1936	Ravalli
Dry Wash	1936	Teton
Drainage	1936	Teton
Sand Coulee Creek	1937	Cascade
Stock Pass	1937	Musselshell
Dodson South Canal	1938	Phillips
Wisconsin Creek	1938	Madison
Cadotte Creek	1939	Lewis and Clark
Spring Creek Run-off	1939	Lewis and Clark
Spring Creek	1939	Lewis and Clark
Keep Cool Creek	1939	Lewis and Clark
Beaver Creek	1939	Lewis and Clark

Appendix 2: Truss Bridges on or eligible for the National Register of Historic Places

Bridge	DOC	Type	County
Fort Benton Bridge	1888/1908	Baltimore	Chouteau
Nixon Bridge	1891/1924	Pratt	Gallatin
West Gallatin River Bridge	1892	Pratt	Gallatin
Big Hole River Bridge	1892	Pratt	Beaverhead
Blaine Spring Creek Bridge	1892	Pratt	Madison
Ten Mile Creek Bridge	1894	Pratt/Pony	L & C
Jefferson River Bridge	1894	Pratt	Gallatin
Musselshell River	1894/1911	Timber	Musselshell
Buhrer - Garrison Ditch Bridge	1895	Pratt	
Dearborn River Bridge	1897	Half-deck	L & C
Tongue River Bridge	1897	Pennsylvania	Custer
Little Prickly Pear Creek Bridge	1897	Warren	L & C
Sample's Crossing	1899	Parker	Fergus
Boulder River Bridge	1899	Pratt	Jefferson
Larson Bridge	1900/1906	Pratt	
Big Hole River Bridge	1901	Warren	Beaverhead
Yellowstone River Bridge	1902	Pennsylvania	Custer
Craig Bridge	1903	Pratt	L & C
Bitterroot Valley Irr. District	1905	Warren	Ravalli
USRS Main Canal Bridge	1907	Pratt	Richland
USRS Main Canal Bridge	1907	Pratt	Richland
Van Buren Street Bridge	1908	Parker	Missoula
Yellowstone River Bridge	1908/1916	Pratt/Penn.	Park
Milk River Bridge	1910	Pennsylvania	Blaine
Pine Creek Bridge	1910	Parker	Park
Reed Point Bridge	1911	Camelback	Stillwater
Main Channel Bridge	1911	Pratt Deck	Sanders
Big Horn River Bridge	1911	Parker	Big Horn
Musselshell River Bridge	1911	Pratt	Musselshell
Flathead River Bridge	1911	Pennsylvania	Flathead
Musselshell River Bridge	1911	Pratt	Musselshell
Milk River Bridge	1911	Parker	Valley
Troy Bridge	1912	Parker	Lincoln
Judith River Bridge	1912	Warren	Fergus
Jefferson River Bridge	1913	Warren	Madison
Snowden Bridge	1913	Parker	Richland
Milk River Bridge	1914	Pratt	Blaine
Dickey Bridge	1914	Warren	Silver Bow
Yellowstone River Bridge	1914	Camelback	Sweet Grass
St. Mary River Bridge	1915	Pratt	Glacier
Browne's Bridge	1915	Warren	Beaverhead
Yellowstone River Bridge	1915	Warren	Yellowstone
Yellowstone River Bridge	1915	Warren	Yellowstone
Intake Bridge (St. Mary)	1915	Pratt	Glacier
Milk River Bridge	1916	Timber	Blaine
Clark Fork's River Bridge	1925	Pratt	Carbon

Bridge	DOC	Type	County
Yellowstone R. Bridge	1926	Warren	Dawson
Wolf Point Bridge	1930	Pennsylvania	Roosevelt
Missouri River Bridge	1933	Warren	L & C

Appendix 3: Steel Stringer Bridges On or Eligible for the National Register of Historic Places

Bridge	DOC	County
Locate Creek	1901	Custer
Mason Creek	1911	Custer
Mizpah Creek	1912	Powder River
Kircher Creek	1912	Custer
North Fork of Sunday Creek	1912	Custer
Spanish Creek	1913	Gallatin
Milk River	1913	Blaine
Red Lodge Creek	1913	Carbon
Pumpkin Creek	1915	Powder River
East Gallatin River	1915	Gallatin
Little Muddy Creek	1923	Cascade
Sand Creek	1925	Rosebud
Great Porcupine Creek	1925	Rosebud
BBWA Canal (Billings)	1925	Yellowstone
Emigrant Creek	1928	Park
BBWA Canal (Billings Heights)	1930	Yellowstone
Northern Pacific Overpass	1931	Powell
Keyser Creek	1935	Stillwater
Five Mile Creek	1938	Yellowstone
Great Northern Overpass	1938	Toole
Orange Street Underpass	1939	Missoula
Ashley Creek	1940	Flathead
Prickly Pear Creek	1941	Lewis & Clark
Drainage (near Plevna)	1942	Fallon
Rattlesnake Creek	1947	Beaverhead

Appendix 4: Steel Girder and Floor Beam Bridges On or Eligible for the National Register of Historic Places

Bridge	DOC	County
Yellowstone River Bridge	1934	Park
Tongue River	1934	Custer
Red Lodge Creek	1935	Carbon
North Fork of Sun River	1936	Lewis & Clark
Marias River	1936	Toole
Clark Fork of Yellowstone River	1939	Carbon
Little Prickly Pear Creek	1940	Lewis & Clark
Ruby River	1945	Madison
Ruby River	1946	Madison
Missouri River (O. S. Warden Bridge)	1951	Cascade
Marias River	1953	Toole
Missouri River	1954	Cascade
Flathead River	1955	Flathead
Missouri River (Fred Robinson Bridge)	1955	Fergus/Phillips
Ten Mile Creek	1955	Lewis & Clark
Bitterroot River	1956	Ravalli

Appendix 5: Reinforced Concrete Arch Bridges On or Eligible for the National Register of Historic Places

Bridge	DOC	County
Fromberg Bridge	1914	Carbon
CMStP & P Overpass	1914	Cascade
Carter Bridge	1922	Park
Kiowa Bridge	1928	Glacier
South Fork of the Milk R. Bridge	1928	Glacier
Vine Street Bridge	1945	Missoula

Appendix 6: Reinforced Concrete T-Beam Bridges On or Eligible for the National Register of Historic Places

Bridge	DOC	County
Bluewater Creek (Fromberg)	1913	Carbon
Conley Street Bridge (Deer Lodge)	1914	Powell
East Rosebud Creek (Roscoe)	1915	Carbon
Red Lodge Creek	1917	Carbon
Keyser Creek Bridge (N. of Columbus)	1931	Stillwater
Tule Creek	1931	Roosevelt
Novak Creek	1931	Cascade
Sheep Creek Bridge	1933	L & C
Midvale Creek (East Glacier)	1933	Glacier
Big Timber Creek	1934	Sweet Grass
Northern Pacific Grade Separation	1934	L & C
Jocko River Bridge	1934	Lake
Wegner Creek Bridge (Craig)	1934	L & C
Fort Shaw Canal (Simms)	1934	Cascade
Belt Creek (Neihart)	1934	Cascade
Northern Pacific Grade Separation	1934	Gallatin
CMstP & P Overpass (Lewistown)	1936	Fergus
Madison River Overflow (Ennis)	1936	Madison
Madison River Overflow #2 (Ennis)	1936	Madison
Burlington Northern Overpass (Dodson)	1936	Phillips
Rock Creek (Roberts)	1938	Carbon
Great Northern Grade Separation	1940	Glacier
West Side Canal (Dillon)	1940	Beaverhead
American Fork (Harlowtown)	1942	Wheatland
Stillwater River (Nye)	1945	Stillwater
Sand Creek (Jordan)	1953	Garfield
Teton River	1953	Chouteau
Little Big Horn River Bridge	1956	Big Horn

Appendix 7: Reinforced Concrete Slab Bridges On or Eligible for the National Register of Historic Places.

Bridge	DOC	County
Big Horn Canal	1910	Big Horn
Warm Springs Creek (Warm Springs)	1912	Deer Lodge
Elk Creek Overflow	1920	Lewis & Clark
Mud Creek (Ronan)	1921	Lake
Bad Route Creek	1921	Dawson
Big Spring Creek (Lewistown)	1930	Fergus
Rey Creek (Logan)	1930	Gallatin
Drainage (Manhattan)	1931	Gallatin
Abbott Creek	1931	Flathead
Flat Canal	1931	Lewis & Clark
Cottonwood Creek (Deer Lodge)	1933	Powell
Irrigation Canal (Belfry)	1934	Carbon
Canal (Belfry)	1937	Carbon
Ferry Creek (Livingston)	1938	Park
Dale Creek (Nye)	1945	Stillwater

Appendix 8: Other Bridges On or Eligible for the National Register of Historic Places

Bridge	DOC	Type	County
Clark Fork River	1912	Rainbow arch	Deer Lodge
Blackfoot River	1947	Plate girder	Missoula
Marias River	1951	Suspension	Liberty

END NOTES

Introduction

1. Five Federal-aid bridges in Montana were found to be critically deficient in 1971. There were, however, 231 off-system bridges that the study found to be in need of replacement in Montana. Bridge Division, Federal Highway Administration. "First Annual Report to Congress: Special Bridge Replacement Program." (Washington DC: Federal Highway Administration, 1971); David Plowden. *Bridges: The Historic Spans of North America.* (New York: The Viking Press, 1974), 240-241; FHWA. *America's Highways, 1776-1976: A History of the Federal-Aid Program.* (Washington, DC: Government Printing Office, 1976), 441-442.

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2. Duane A. Smith. *Rocky Mountain Mining Camps: The Urban Frontier.* (Lincoln: University of Nebraska Press, 1967), 54-55; Carl F. Wohlgenant, Jr. "Development of the Federal-Aid Highway System in Montana." (Unpublished Masters Thesis, University of Montana, 1954), 18-19; Montana Highway Commission. *History of the Montana State Highway Department, 1913-1942.* (Helena: Montana Highway Commission, 1943), 3; *Acts, Resolutions and Memorials of the Territory of Montana.* (Virginia City, Montana: D. W. Tilton & Co., 1866), 24-24; Burlingame, *The Montana Frontier*, 145-146.

3. Michael Malone, Richard Roeder and William Lang. *Montana: A History of Two Centuries.* Revised Edition. (Seattle: University of Washington Press, 1991), 75; Burlingame, *The Montana Frontier*, 145-146; *House Journal of the First Session of the Legislative Assembly of the Territory of Montana, December 12, 1864 - February 9, 1865.* (Bozeman: No Publisher, 1865).

4. In 1899, Gallatin and Madison counties jointly funded the construction of new bridge approximately one mile north of the original crossing. This bridge remained in use until it was replaced in 1961. Madison County History Association. *Pioneer Trails and Trials: Madison County, 1863 - 1920.* (Great Falls: Blue Print & Letter Company, 1976), 809; "New Bridge on the Jefferson." *Montana Post*, May 12, 1866.

5. Montana Territory vs. Virginia City and Summit City Wagon Road Company, 1871. Small Collections No. 509. Montana Historical Society, Helena, Montana; Malone, Roeder and Lang, *Montana*, 102; Montana Highway Commission, *History of the Montana State Highway State Highway Department*, 5; Smith, *Rocky Mountain Mining Camps*, 54-55; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 20; *General Laws, and Memorials and Resolutions of the Territory of Montana.* (Virginia City, Montana: D. W. Tilton & Co., 1868), 32-34; *Laws, Memorials and Resolutions of Montana, Passed at the Sixth Session of the Legislative Assembly, December 6, 1869 - January 7, 1870.* (Helena: Robert E. Fisk, 1870), 44, 90.

6. Malone, Roeder and Lang, *Montana*, 75; Smith, *Rocky Mountain Mining Camps*, 55.

7. Montana Highway Commission, *History of the Montana State Highway Department*, 5-7.

8. William L. Hall. *Financing Modern Highways for Montana.* (Helena: Montana Fact Finding Committee on Highways, Streets and Bridges, 1956), 3; Malone, Roeder and Lang, *Montana*, 75.

9. Quivik, *Historic Bridges in Montana*, 10; Smith, *Rocky Mountain Mining Camps*, 54-55.

10. The Yankee Jim toll road and Browne's Bridge were the last two toll bridges. The Yankee Jim road in Park County ceased operation in 1893 when the county assumed control of it. Browne's Bridge remained in operation until its owner's death in 1908. The county replaced the original bridge with the existing structure in 1915/16. Doris Whithorn. *Yankee Jim's National Park Toll Road and the Yellowstone Trail.* (Privately Published, 1989), 28; Hall, *Financing Modern Highways for Montana*, 3; Wohlgenant, "Development of the Federal-Aid Highway System of Montana", 22.

11. Wohlgenant, " Development of the Federal-Aid Highway System of Montana", 22; Burlingame, *The Montana Frontier*, 145-146; Sturgis Family Papers. Correspondence and Affidavits (1862-1866). Small Collection No. 809. Montana Historical Society. Helena, Montana; Malone, Roeder and Lang, Montana, 233; Quivik, *Historic Bridges in Montana*, 18.

12. Malone, Roeder and Lang, *Montana*, 172; David Plowden. *Bridges: The Spans of North America.* (New York: The Viking Press, 1974), 63; J. A. L. Waddell. *Bridge Engineering.* Volume 1. (New York: John Wiley & Sons, 1916), 22; Quivik, *Historic Bridges in Montana*, 23.

13. Montana Highway Commission. *History of the Montana State Highway Department*, 8; Quivik, *Historic Bridges in Montana*, 28.

14. Ellis L. Armstrong. *History of Public Works in the United States.* (Chicago: American Public Works Association, 1976), 110; Plowden, *Bridges*, 65.

15. Robert Newberry and H.W. Guy Meyer. "Ordinary Iron Highway

Bridges." *Wisconsin Academy Review*, 30, (March, 1984), 34-35; Plowden, *Bridges*, 67; Frederic L. Quivik. "Montana's Minneapolis Bridge Builders." *IA: The Journal of the Society for Industrial Archeology*, 10 (1984), 47.

16. Steven R. Rae, et al. *New Mexico Historic Bridge Survey.* (Santa Fe: New Mexico State Highway and Transportation Department, 1987), 7; Milo S. Ketchum. *The Design of Highway Bridges of Steel, Timber and Concrete.* (New York: McGraw-Hill Book Company, 1920), 426-427; Joseph Gies. *Bridges and Men.* (New York: Doubleday & Company, 1963), 130.

17. Quivik, "Montana's Minneapolis Bridge Builders", 38; Ibid, *Historic Bridges in Montana*, 33; Plowden, *Bridges*, 185.

18. Montana Good Roads Congress. *Minutes of the Proceedings of the Montana Good Roads Convention, Held at Billings, Montana, June 16th, 17th, 18th, 1910.* (Helena: The Montana Lookout Press, 1910), 17-21; Hall, *Financing Modern Highways for Montana*, 4; Patrick M. Morris. "The Good Road Movement and Montana to 1916." (Missoula: Unpublished Masters Thesis, University of Montana, 1967), 57.

19. Quivik, "Montana's Minneapolis Bridge Builders", 41; Plowden, *Bridges*, 67.

20. Quivik, "Montana's Minneapolis Bridge Builders", 41-44; Quivik, *Historic Bridges in Montana*, 33.

21. Quivik, "Montana's Minneapolis Bridge Builders", 45.

22. Peppard built the first Higgins Avenue Bridge in Missoula around 1892. In 1908, the bridge was destroyed during a flood. It was replaced by a timber structure and, eventually, a girder structure. Two of the original bridge's spans, however, were saved and relocated on Van Buren Street where they are still located. The spans are currently used as a pedestrian crossing. Steve Cohen. *Missoula County Images.* (Missoula: Pictorial Histories Publishing Company, 1982), 11 - 16; Quivik, *Historic Bridges of Montana*, 39 - 40.

23. Quivik, *Ibid*, 40.

24. The counties were primarily responsible for bridge construction in their districts. Because of special interest groups, such as the Yellowstone Trail Foundation, it appears that many roads were built through subscriptions or funded by local business groups. Malone, Roeder and Lang, *Montana*, 237, 238, 242, 249; Quivik, *Historic Bridges in Montana*, 28-31.

25. Gies, *Bridges and Men*, 228.

26. Malone, Roeder and Lang, *Montana*, 252; Montana Highway Commission, *History of the Montana State Highway Department*, 8-12;

27. Montana Highway Commission, *Ibid*, 8-12; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 39-40.

28. Montana Highway Commission. *History of the Montana State Highway Department*, 9-12; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 31-32.

29. Hall, *Financing Modern Highways for Montana*, 3; Montana Highway Commission. *History of the Montana State Highway Commission*, 11.

30. Montana Highway Commission, *History of the Montana State Highway Department*, 12-13; George R. Metlen. *Report of the Montana State Highway Commission for the Years 1915-1916.* (Helena: Independent Publishing Co., 1916), 5; Milo S. Ketchum. *The Design of Highway Bridges of Steel, Timber and Concrete.* Second Edition. (New York: McGraw-Hill Book, Inc., 1920), 158-159, 264-265, 273-276.

31. Montana Highway Commission, *History of the Montana State Highway Department*, 12-13, 102.

32. For crossings less than 40-feet, the department designed timber, reinforced concrete and steel girder bridges. Since the timber bridges seldom cost more than $500 to construct, the Department did not become heavily involved in their construction until the late 1920s. Montana Highway Commission, *History of the Montana State Highway Department*, 13; Metlen, *Report of the Montana State Highway Commission*, 5-6; Montana Highway Commission. *Second Biennial Report, State Highway Commission of Montana, 1919 - 1920.* (Helena: Independent Publishing Company, 1920), 63.

33. Montana Highway Commission. *First Biennial Report of the State Highway Commission, 1917 - 1918.* (Helena: Independent Publishing Company, 1918), 11.

34. Montana Highway Commission. *First Biennial Report of the State Highway Commission*, 11; Ellis L. Armstrong. *History of Public Works in the United States.* (Chicago: American Public Works Association, 1976), 115.

35. Metlen, *Report of the Montana Highway Commission*, 7

36. Montana Highway Commission. *History of the Montana State Highway Department*, 13-14,22; Thomas Agg. "Federal Aid for Roads: Why Past Accomplishment Urges Its Continuance." *Engineering News-Record*, (January 2, 1930), 21; Wohlgenant, "Development of the Federal-Aid System in Montana", 45.

37. Malone, Roeder and Lang, *Montana*, 281-283; Montana Highway Commission, *History of the Montana State Highway Department*, 22.

38. Montana Highway Commission, *Ibid*, 22-24; Wohlgenant, "Development of the Federal-Aid System in Montana", 45; Quivik, "Inventory and Assessment of Timber Bridges on Montana's On-system and Off-system Roadways." Prepared for Montana Department of Highways by GCM Services, Inc., 1986, 2.

39. Quivik, *Ibid*, 3; Rae, *New Mexico Historic Bridge Survey*, 56.

40. Bridge Inspection and Correspondence files. Montana Department of Transportation, Helena, Montana.

41. Bridge Inspection and Correspondence Files, *Ibid.*

42. Billings City Directories, 1932 - 1991. Montana Department of Transportation Bridge Inspection Files, Helena, Montana.

43. Tom Stout, ed. *Montana: Its Story and Biography.* Three volumes. (Chicago: The American Historical Society, 1921), 2:221-222; Billings City Directories, 1913 - 1991.

44. Malone, Roeder and Lang, *Montana*, 292, 296; Wohlgenant, "Development of the Federal-Aid System in Montana", 57-58; Montana Highway Commission, *History of the Montana State Highway Department*, 27-28; Montana Highway Department. "Financial Survey of the State-wide Planning Survey." (Helena: Montana Highway Department, 1936), 56.

45. Malone, Roeder and Land, *Montana*, 296; Montana Highway Commission, *History of the Montana State Highway Department*, 30-31; "A New Highway Era." *Engineering News-Record*, (January 18, 1934), 65070; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 60; Montana Highway Department, "Financial Survey of the State-wide Planning Survey", 57.

46. Malone, Roeder and Lang, *Montana*, 295; Interview with John Morrison by John Terreo, November, 1988. Oral History No. 1136. Montana Historical Society. Helena, Montana.

47. Morrison Interview; Federal Highway Administration, *America's Highways*, 433.

48. Montana Highway Commission, *History of the Montana State Highway Department*, 34.

49. Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 66-67; Federal Highway Administration, *America's Highways*, 432-433; Montana Highway Commission, *History of the Montana State Highway Department*, 38-39.

50. Montana Highway Commission. *Montana Highway History, 1943-1959.* (Helena: Montana Highway Commission, 1960), 1-3.

51. Paul Anderson. *The Benbow Mine and Mill and the Mouat Mine in the Stillwater Complex, Stillwater County, Montana.* Report Prepared for the Department of State Lands by GCM Services, Inc., Butte, Montana, 1990, 8-9.

52. Montana Secondary roadway standards were not as stringent as primary road standards. Narrower road widths, steeper grades and gravel surfacing and sharper curves were common. Montana Highway Commission, *Montana Highway History*, 3; Armstrong, *History of Public Works in the United States*, 117.

53. Montana Highway Commission, *Montana Highway History*, 3; Automotive Safety Foundation. *Moving Ahead on Montana's Highways: An Engineering Study of Road and State Needs*. (Helena: Montana Highway Commission, 1956), 47-48; Armstrong, *History of Public Works in the United States*, 117.

54. Plowden, *Bridges*, 290.

55. Montana State Highway Planning Survey, *Montana's Highway Problems*, 11-12, 33-34.

56. American Association of State Highway Transportation Officials. *Standard Specifications for Highway Bridges*. Sixth Edition. (Washington, DC: AASHTO, 1953), xxvii-xxviii.

57. Montana Highway Commission, *Montana Highway History*, 19.

58. Montana Highway Commission, *Montana Highway History*, 25; Montana State Highway Planning Survey, *Montana's Highway Problems*, 27, 42-43.

59. Montana Highway Commission, *Montana Highway History*, 29, 34; Automotive Safety Foundation, *Moving Ahead on Montana's Highways*, 48.

60. Armstrong, *History of Public Works in the United States*, 117.

Part 2: Timber Bridges

1. P. A. C. Spero & Company. *Delaware Historic Bridge Inventory and Evaluation*. (Baltimore: P. A. C. Spero & Company, 1991), 25.

2. Frederic L. Quivik. "Inventory and Assessment of Timber Bridges on Montana On-System and Off-System Roadways." Prepared for Montana Department of Highways by GCM Services, Inc., 1986.

3. The two oldest timber still in use in Montana are located in Lewis and Clark and Cascade counties. Both structures were constructed in 1900 and are of similar design. The first Montana Highway Commission-designed timber bridge was constructed in Sheridan County in 1915; Quivik, "Ibid", 2.

4. Milo S. Ketchum. *The Design of Highway Bridges of Steel, Timber and Concrete*. Second Edition. (New York: McGraw-Hill Book Company, Inc., 1920), 255-257.

5. Malone, Roeder and Lang, *Montana*, 280-283.

6. Other fabricating plants supplying components to Montana bridge contractors were the Spokane-based Washington Wood Preserving Company (64 bridges), National Pole & Treatment Company (49 bridges), the Pope & Talbot Lumber Company of Portland, Oregon (31 bridges) and the C. R. McCormick Lumber Company, also of Portland. Quivik, "Inventory and Assessment of Timber Bridges . . . .", 2.

7. W. P. Roscoe dominated the construction of steel truss and concrete bridges during the late 1920s and 1930s. His company built at least 44 timber bridges in Montana between 1934 and 1940. The D. M. Manning Company built 42 timber structures in the state during the 1930s. Quivik, *Historic Bridges in Montana*, 43.

8. Other out-of-state bridge contractors working in Montana included the Minot-based Dakota Concrete Company, McNutt Brothers of Eugene, Oregon, James Crick of Spokane, C. A. Wagner of Sioux Falls, South Dakota and Nolan Brothers of Minneapolis.

9. Malone, Roeder and Lang, *Montana*, 296-297; Montana Highway Commission. *History of the Montana State Highway Department*, 30-31; "A New Highway Era." *Engineering News-Record* (January 18, 1934), 65-70; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 60.

10. Malone, Roeder and Lang, *Montana*, 302; James T. Patterson. *The New Deal and the States: Federalism in Transition.* (Princeton, New Jersey: Princeton University Press, 1969), 229; Wohlgenant, "Development of the Federal-Aid Highway System in Montana", 65.

11. Planning Survey Division. *Montana Highway History, 1943-1959.* (Helena: Montana Highway Commission, 1960), 1-7.

12. Planning Survey Division, *Ibid*, 7-11; Quivik, "Inventory and Assessment of Timber Bridges . . . .", 3.

Part 3: Truss Bridges

1. Plowden, *Bridges: The Spans of North America.* (New York: The Viking Press, 1974), 40; Federal Highway Administration. *America's Highway's, 1776-1976: A History of the Federal-Aid Program.* (Washington, DC: Government Printing Office, 1976), 421; Eckel. "The Development of Simple Types of Bridge Structures in the United States.", *The Colorado Engineer* 25 (November, 1928), 11.

2. Eckel, "The Development of Simple Types of Bridge Structures in the United States.", 11; Plowden, *Bridges*, 62; J.A.L. Waddell. *Bridge Engineering.* Volume 1 (New York: John Wiley & Sons, Inc., 1916), 31. Carl Condit. *American Building.* (Chicago: University of Chicago Press, 1968), 94-95.

3. Because of the enormous size of the railroad and highway expansion program during the late 19th century, American engineers were challenged by the railroad companies to build many bridges as economically as possible. Pin-connections allowed for rapid construction and were relatively inexpensive. Joseph Gies. *Bridges and Men.* (New York: Doubleday & Company, Inc., 1963), 132.

4. Plowden, *Bridges*, 62.

5. FHWA, *America's Highways*, 423; Waddell, *Bridge Engineering*, 31.

6. Eckel, "The Development of Simple Types of Highway Structures in the United States.", 11; Robert Newberry and H.W. Guy Meyer. "Ordinary Iron Highway Bridges." *Wisconsin Academy Review*, 30 (March, 1984), 34; Waddell, *Bridge Engineering*, 17; Plowden, *Bridges*, 126; Gies, *Bridges and Men*, 130.

7. Plowden. *Bridges*, 34; Waddell, *Bridge Engineering*, 3.

8. Plowden, *Ibid*, 38-39; Waddell, *Ibid*, 20-21.

9. Waddell, *Bridge Engineering*, 21; Plowden, *Bridges*, 64-65, 185.

10. Quivik, *Historic Bridges in Montana*, 55; Condit, *American Building*, 143.

11. Eckel. "The Development of Simple Types of Highway Structures in the United States.", 11; Plowden, *Bridges*, 62; Metlen, *Report of the Montana State Highway Commission*, 5-6; Frederic L. Quivik. *Historic Bridges in Montana.* (Washington, DC: Department of the Interior, 1982), 46.

12. Interview with Jack Walsh, MDT Bridge Maintenance Engineer by Jon Axline, February 26, 1992.

13. Condit, *American Building*, 215 - 216.

14. Condit, *Ibid*, 216.

15. Quivik, *Historic Bridges in Montana*, 64.

16. Montana Highway Commission, *History of the Montana State Highway Department*, 6B-6C; Interview with John Morrison by John Terreo, November, 1988. Oral History No. 1136. Montana Historical Society, Helena, Montana.

Part 4: Steel Girder Bridges

1. David Plowden. *Bridges: The Spans of North America.* (New York: The Viking Press, 1974), 171.

2. C. L. Eckel. "The Development of Simple Types of Bridge Structures in the United States." *The Colorado Engineer*, 25 (November, 1928), 11; Ellis L. Armstrong. *History of Public Works in the United States.* (Chicago: American Public Works Association, 1976), 110); Milo S. Ketchum. *The Design of Highway Bridges of Steel, Timber and Concrete.* (New York: McGraw-Hill Book Company, Inc., 1920), 157; J.A.L. Waddell. *Bridge Engineering.* (New York: John Wiley & sons, Inc., 1916), 18

3. P.A.C. Spero & Company. *Delaware Historic Bridges Survey and Evaluation.* (Baltimore: Spero & Company, 1990), 147-148; Ketchum. *The Design of Highway Bridges*, 145.

4. Michael Malone, Richard Roeder and William L. Lang. *Montana: A*

History of Two Centuries. Revised Edition. (Seattle: University of Washington Press, 1991), 242, 252.

5. Malone, Roeder and Lang, *Ibid*, 281-283.

6. Malone, Roeder and Lang, *Ibid*, 297-302; Montana Highway Commission. *History of the Montana State Highway Department, 1913 - 1942*. (Helena: Montana Highway Commission, 1943), 28-29; Carl Wohlgenant. "Development of the Federal-Aid Highway System in Montana." (Unpublished Masters Thesis, University of Montana, 1954), 58-60.

7. Malone, Roeder and Lang, *Montana*, 308-311; Montana State Highway Planning Survey. *Preliminary Report on Highway Needs in Montana: Montana's Highway Problems*. (Helena: Montana Highway Commission, 1948), 34; Montana Highway Commission. *Montana Highway History, 1943-1959*. (Helena: Montana Highway Commission, 1960), 1-3.

8. Fabricating companies operating in Montana were located in Chicago, Minnesota, Colorado, Wisconsin, Virginia, Oklahoma, Washington, Iowa, Indiana and Kansas.

9. On many bridges in Flathead County, however, county and state bridge builders placed log stringers between the girders to save construction costs.

10. Spero. *Delaware Historic Bridges Survey and Evaluation*, 148.

11. Waddell. *Bridge Engineering*, 18; Plowden, *Bridges*, 70-71.

12. Ketchum. *The Design of Highway Bridges*, 157-158; Armstrong. History of Public Works in the United States, 117; Federal Highway Administration. *Bridge Inspector's Training Manual*. (Washington, DC: U.S. Department of Transportation, 1979), 2-5; David Jacobs and Anthony E. Neville. *Bridges, Canals & Tunnels: The Engineers Conquest of America*. (Washington, DC: American Heritage Publishing Co., Inc., 1968), 139.

Part 5: Reinforced Concrete Bridges

1. H. J. Hopkins. *A Span of Bridges*. (New York: Praeger Publishers, 1970), 247; David Plowden. *Bridges: The Spans of North America*. (New York: The Viking Press, 1974), 297-298; C. L. Eckel. "The Development of Simple Types of Bridge Structures in the United States." *The Colorado Engineer*, 25 (November, 1928), 34.

2. The production of portland cement in the United States rose from 8 million barrels in 1900 to approximately 76 million barrels in 1910. Production of the cement had reached over 150 million barrels in 1925. The boom in portland cement production was directly tied to the improvement in reinforced concrete technology. "The Story of Cement, Concrete and Reinforced Concrete." *Civil Engineering* 47 (November, 1977), 64; David Jacobs and Anthony E. Neville. *Bridges, Canals and Tunnels: The Engineering Conquest of America*. (Washington, DC: American Heritage Publishing Co., 1968), 104; Federal

Highway Administration. *America's Highways, 1776 - 1976: A History of the Federal-Aid Program.* (Washington, DC: GPO, 1976), 428; Condit, *American Building*, 176; Hopkins, *A Span of Bridges*, 247-248; Plowden, *Bridges*, 298-299.

3. Henry Grattan Tyrell. *History of Bridge Engineering.* (Chicago: Published by the Author, 1911), 408-409; J. A. L. Waddell. *Bridge Engineering* Volume 1 (New York: John Wiley & Sons, 1916), 28; Carl Condit. *American Building.* (Chicago: University of Chicago Press, 1968), 158, 175; Plowden, *Bridges*, 298-300; Roger H. Corbetta. "Evolution of Concrete Construction." *Journal of the American Concrete Institute*, 25 (February, 1954), 501

4. Plowden, *Ibid*, 320; P.A. C. Spero & Company. *Delaware Historic Bridges Survey and Evaluation.* (Baltimore: Spero & Company, 1991), 88; Corbetta, "Evolution of Concrete Construction," 501.

5. Spero, *Ibid*, 89; Interview with Jack Walsh, Montana Department of Transportation Bridge Maintenance Engineer, by Jon Axline, February 14, 1992.

6. Plowden. *Bridges*, 299-300; Jacobs and Neville. *Bridges, Canals and Tunnels*, 104; "The Story of Cement, Concrete and Reinforced Concrete." *Civil Engineering*, 64.

7. Charles S. Whitney. *Bridges: A Study in Their Art, Science and Evolution.* (New York: William Edwin Rudge, Publisher, 1929), 191; Tyrell, *History of Bridge Engineering*, 447; FHWA, America's Highways, 428; Condit, *American Building*, 251.

8. Concrete formwork was generally the most expensive portion of the construction process, absorbing anywhere from 10 - 60% of the total construction cost of the bridge. Jeffrey A. Hess and Robert M. Frame III. *Historic Highway Bridges in Wisconsin: Stone and Concrete-Arch Bridges.* Volume 1. (Madison: Wisconsin Department of Transportation, 1986), 199; Plowden, *Bridges*, 247-248; *Bridge Inspection Training Manual.* (FHWA: U.S. Department of Transportation, 1979), G-4.

9. Spero. *Delaware Historic Bridges Survey*, 123; Condit. *American Building*, 169; Plowden, *Bridges*, 247-248.

10. Other Montana concrete bridge builders included Mougey & Whitaker of Bozeman, the T. W. McGeever, P. E. Rafferty, Charles Goddard and Lawler Corporation all of Butte, Boomer & Blakeslee and Fred Dudley of Great Falls and the Helena-based McKinnon-Decker Company. Other construction companies were located in Libby, Kalispell, Whitefish, Charlo, Anaconda, Livingston and Missoula.

11. James Crick of Spokane, the Midland Bridge and Construction and F. A. Massman Construction companies of Kansas City, Missouri, the Omaha-based Inland Construction Company and the Woodward Construction Company of Rock Springs, Wyoming were also active in the state.

12. Interview with John Morrison by John Terreo, November, 1988. Oral History No. 1136. Montana Historical Society, Helena, Montana.

13. James R. McDonald. "Historic Structures Report, Montana State Prison." Prepared for the Powell County Museum and Arts Foundation, Deer Lodge, Montana, 1979, 60-61.

14. Minutes, Montana Prison Commissioners, August, 8, 1911, 90; *Montana State Penitentiary, Annual Report, 1914.* (Deer Lodge: No Publisher, 1914), 16.

15. *Bridge Inspectors Training Manual*, G-37; Ketchum, *The Design of Highway Bridges*, 345.

16. Ketchum, *Ibid*, 345; Condit, *American Building*, 175; FHWA. *America's Highways*, 432; Plowden, *Bridges*, 320.

17. Plowden, *Bridges*, 320.

18. James R. McDonald. "Historic Structures Report: Montana State Prison." Prepared for the Powell County Museum and Arts Foundation, Deer Lodge, Montana, 1979, 19-20.

19. Contractors included W. K. Trippett of Whitefish, T. W. McGeever of Butte, D. J. O'Neil & Son and B. N. Crenshaw of Livingston and the H. B. Berky Company of Bozeman. James Crick was the sole out-of-state contractor who built this type of bridge in Montana.

20. FHWA, *America's Highways*, 434-435; Condit, *American Building*, 257.

21. Plowden. *Bridges*, 321; FHWA, *America's Highways*, 433.

22. Gies, *Bridges and Men*, 230.

23. Gies, *Ibid*, 230.

24. Armstrong, *History of Public Works in the United States*, 117; Plowden, *Bridges*, 321.

25. Plowden, *Ibid*, 321; Federal Highway Administration. *America's Highways*, 434-435; *Pre-tensioned Bonded Prestressed Concrete*. Catalogue Bulletin No. PC-945. (Trenton, New Jersey: John A. Roeblings Sons, 1957), 4.

26. Minutes, Montana Prison Commissioners, August 8, 1911, 90.

27. "Longest Marsh Arch Bridge in the Nation is Nominated to the Register." *Kansas Preservation: Newsletter of the Historic Preservation Department, Kansas State Historical Society*. XIV (January - February, 1992), 1 - 2.

28. Montana Cultural Resources Inventory: Concrete Bridge - Old County Highway (24DL411). State Historic Preservation Office, Helena, Montana.

29. Frederick Rings. *Reinforced Concrete Bridges*. (New York: Von Nostrand Co., 1913), 1.

Part 6: Others

1. Patricia Ingram. "Historic Transportation Routes Through Southwestern Montana." (Dillon: Bureau of Land Management, 1976), 59-65; Correspondence, Joel Overholser to Jill Bakke, July 19, 1988. Montana Historical Society, Helena, Montana.

2. "The Captains of the River." *Billings Gazette*, July 27, 1980.

Part 7: Conclusion

1. David Plowden. *Bridges: The Spans of North America.* (New York: The Viking Press, 1974), 140.

2. There are no rigid frame concrete bridges in Montana. Rigid frame concrete bridges were popular with bridge builders throughout the country from the mid-1930s until the late 1950s. In Montana, timber bridges functioned in the same capacity as rigid frame structures in other states.

3. *Colorado Bridge Survey.* (Loveland, Colorado: Fraser Design, 1983), 4.

Part 8 - The Bridges

1. Ken Karzmiski. "Madison Toll Bridge." from Ken and Sheri Deaver's *Archeological Site Testing and Evaluation on the Beartrap Canyon of Madison County, Montana.* Report prepared for the Bureau of Land Management (1984), A12 - A16.

2. Quivik, *Historic Bridges in Montana*, 53-55.

3. Bridge Inspection Record No. L31089001+0.400-1. Montana Department of Transportation, Helena, Montana.

4. Roberta Carkeek Cheney. *Names on the Face of Montana:The Story of Montana's Place Names.* (Missoula: Mountain Press Publishing Company, 1983), 186; J. D. Dwyer, Mineral County Clerk to Forestry Department, Missoula, Montana, November 20, 1916. Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana; Dwyer to District Forester, Missoula, Montana, April 5, 1917.

5. J. D. Dwyer to District Forester, "Ibid", April 5, 1917; Ray B. Leib, County Engineer to the Board of County Commissioners, May 1, 1917. Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana; Wausau Iron Works to Dwyer, May 23, 1917. Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana; Leib to the Mineral County Commissioners, June 7, 1917. Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana.

6. G. H. Lantz, District Engineer to the Board of County Commissioners, June 26, 1917. Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana; Lantz to County Commissioners, October 27, 1917, Clerk and Recorders Office, Mineral County Courthouse, Superior, Montana.

7. "Fred Robinson Bridge Rites at Noon Today." *Great Falls Tribune*, August 16, 1959; Montana Highway Commission. *Report of the State Highway Commission of Montana for the Biennium Ending December*, 1930. (Great Falls: Tribune Printing Co., 1931), 43, 45-47.

8. Montana Highway Commission, *Report of the State Highway Commission*, 45 - 47.

9. "Is a Bridge Across the Missouri Justified?" *Lewistown Daily News*, March 1, 1950; "Fred Robinson Bridge Rites at Noon Today", *Great Falls Tribune*, August 16, 1959.

10. Bridge Inspection Record No. P00061088+0.067-1. Montana Department of Transportation, Helena, Montana; "Fred Robinson Bridge Rites at Noon Today", *Great Falls Tribune*, August 16, 1959.

11. Montana Highway Commission. *Montana Federal-Aid Primary Systems: Bridge Record for Defense Requirements.* (Helena: Montana Highway Commission, 1950), 6; Billings City Directories, 1923, 1932, 1940, 1947.

12. Montana State Engineer's Office. *Water Resources Survey: Phillips County.* (Helena: Water Resource Board, 1968), 57; Phillips County Historical Society. *The Yester-Years.* (Havre: Griggs Printing & Publishing Co., 1978), 229; Montana Highway Commission. *Montana Federal-Aid Primary Systems*, 59.

13. Waddell, *Bridge Engineering*, 737; Quivik, *Historic Bridges in Montana*, 55.

14. Correspondence, Scott R. Hart, Division Engineer to the Montana Highway Department, November 18, 1933. Snowden - South Feeder Road (WO-1044). Montana Department of Transportation, Helena, Montana.

15. "First Traffic Rolls Over New Missoula Bridge." *The Daily Missoulian*, July 3, 1937; "Span Dedicated Formally, Called Parkway Bridge", *Ibid*, July 17, 1937.

16. "Orange Street Bridge Nostalgia: Span's Special to its Builder." *Missoulian*, July 3, 1987.

17. Malone, Roeder and Lang, *Montana*, 296.

18. Memorandum to H. W. Holmes from R. A. Stephenson, *Shelby Overpass (FAGM 243-D)*. February 27, 1945; Memorandum to A. G. Middleton from R. A. Stephenson, March 20, 1945; Memorandum to H. W. Holmes from R. A. Stephenson, April 6, 1945. Bridge Archives (P00067000+0.086-1). Montana Department of Transportation, Helena, Montana.

19. "O.S. Warden, 85, Publisher of the Tribune, Dies at Home." *Great Falls Tribune*, March 12, 1951; "O.S. Warden Bridge Dedication Features Second Day of Fall Festival." *Ibid*, September 14, 1951.

20. "O.S. Warden Bridge Dedication Features Second Day of Fall Festival Here." *Great Falls Tribune*, September 14, 1951; "Bonner Cites Warden's Road Vision." *Ibid*, September 15, 1951.

21. "The Work Has Started." *Fromberg Herald*, July 23, 1914; Carbon County Bridge Record. Clerk and Recorders Office, Carbon County Courthouse, Red Lodge, Montana. Condit. *American Building*, 251.

22. Reinforcing steel for the bridge was provided by an unknown Kansas City, Missouri fabricator. The Carbon County Bridge Record indicates that it was designated a "3000 Style Q Support." *Fromberg Herald*, ibid; Fromberg Service Club. *Fromberg: "The Fruitbasket of Carbon County."* (Billings: Empire Publishing, 1976), 7-8; Carbon County Bridge Record, Ibid. The plans upon which the bridge is based, are located in the Carbon County Clerk and Recorders Office.

23. One of the bridge's designers, Ralph Adams, was an agent for the Trussed-Concrete Steel Company (TRUSCON). The company was founded by Julius Kahn, the inventor of the trussed bar used for reinforcing concrete arches. The trussed bar was a "flat bar with the outside edges cut and bent upward to form shear reinforcement." The bar was developed in 1903. Lon Johnson and Mitzi Rossillon. Historic American Engineering Record: Tenth Street Bridge (HAER No. MT-8). Prepared for the National Park Service by RTI Inc., 1992; Montana Highway Commission. *Second Biennial Report of the State Highway Commission of Montana, 1919-1920.* (Helena: Independent Publishing Company, 1920), 65.

24. Montana Highway Commission, *Ibid*, 65

25. "After 67 Years, Bridge Ill But Graceful Still." *Great Falls Tribune*, February 8, 1987.

26. Quivik, *Historic Bridges in Montana*, 69.

27. Montana Highway Planning Survey. Bridge Condition Survey No. 118-0890-0384 (Drawing 401-A). Montana Department of Transportation, Helena, Montana.

28. Evarts Blakeslee first appears as a general contract in the 1923 Great Falls city directory. By 1925, he had gone into business with Angus McGuire, a partnership that lasted until about 1931. In 1934, the city directory listed him in partnership with Robert Boomer, an employee of the Anaconda Wire & Cable Co. That association continued until 1936. From 1937 until 1944 Blakeslee worked as a bridge contractor. He was the president of Utility Builders Incorporated from 1949 until his death in 1968.

29. Charles Goddard arrived in Butte in 1896. Initially employed as a mason, he operated a general contracting firm from circa 1900 until his retirement in 1941. Goddard did not specialize in bridge construction and he built only two bridges in Montana during his career.

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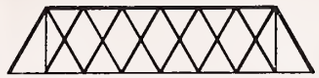
LENTICULAR (PARABOLIC)

1878 - EARLY 20TH CENTURY

A PRATT WITH BOTH TOP AND BOTTOM CHORDS PARABOLICLY CURVED OVER THEIR ENTIRE LENGTH.

LENGTH: 50-360 FEET
5-110 METERS

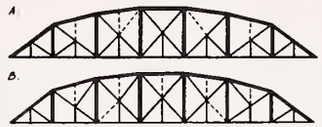


DOUBLE INTERSECTION WARREN
(LATTICE)

MID 19TH-20TH CENTURY

STRUCTURE IS INDETERMINATE. MEMBERS ACT IN BOTH COMPRESSION AND TENSION. TWO TRIANGULAR WEB SYSTEMS ARE SUPERIMPOSED UPON EACH OTHER WITH OR WITHOUT VERTICALS.

LENGTH: 75-400 FEET
23-120 METERS



PENNSYLVANIA (PETIT)

1875-EARLY 20TH CENTURY

A. A PARKER WITH SUB-STRUTS.
B. A PARKER WITH SUB-TIES.

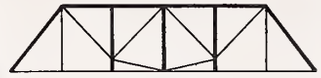
LENGTH: 250-600 FEET
75-180 METERS

WARREN

WITH VERTICALS
MID 19TH-20TH CENTURY

DIAGONALS CARRY BOTH COMPRESSIVE AND TENSILE FORCES. VERTICALS SERVE AS BRACING FOR TRIANGULAR WEB SYSTEM.

LENGTH: 50-400 FEET
15-120 METERS

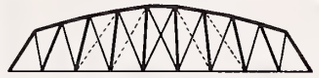


GREINER

1894 - EARLY 20TH CENTURY

PRATT TRUSS WITH THE DIAGONALS REPLACED BY AN INVERTED BOWSTRING TRUSS

LENGTH: 75-250 FEET
23-75 METERS



PEGRAM

1887 - EARLY 20TH CENTURY

A HYBRID BETWEEN THE WARREN AND PARKER TRUSSES, UPPER CHORDS ARE ALL OF EQUAL LENGTH.

LENGTH: 150-630 FEET
45-195 METERS

KING POST

(WOOD)

A TRADITIONAL TRUSS TYPE WITH ITS ORIGINS IN THE MIDDLE AGES.

LENGTH: 20-60 FEET
6-18 METERS

PRATT

1844 - 20TH CENTURY

DIAGONALS IN TENSION, VERTICALS IN COMPRESSION, (EXCEPT FOR HIP VERTICALS ADJACENT TO INCLINED END POSTS).

LENGTH: 30-250 FEET
9-75 METERS

HOWE

1840 - 20TH CENTURY

(WOOD, VERTICALS OF METAL)

DIAGONALS IN COMPRESSION, VERTICALS IN TENSION.

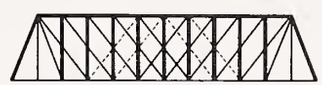
LENGTH: 30-150 FEET
9-45 METERS

CAMELBACK

LATE 19TH-20TH CENTURY

A PARKER WITH A POLYGONAL TOP CHORD OF EXACTLY FIVE SLOPES

LENGTH: 100-300 FEET
30-90 METERS



DOUBLE INTERSECTION PRATT

1847 - 20TH CENTURY

(WHIPPLE, WHIPPLE-MURPHY, LINVILLE)

AN INCLINED END POST PRATT WITH DIAGONALS THAT EXTEND ACROSS TWO PANELS.

LENGTH: 70-300 FEET
21-90 METERS

POST

1865 - LATE 19TH CENTURY

A HYBRID BETWEEN THE WARREN AND THE DOUBLE INTERSECTION PRATT.

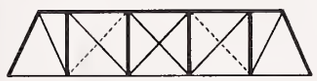
LENGTH: 100-300 FEET
30-90 METERS

QUEEN POST

(WOOD)

A LENGTHENED VERSION OF THE KING POST.

LENGTH: 20-80 FEET
6-24 METERS

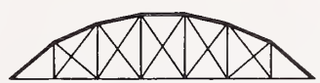


PRATT HALF-HIP

LATE 19TH-EARLY 20TH CENTURY

A PRATT WITH INCLINED END POSTS THAT DO NOT HORIZONTALLY EXTEND THE LENGTH OF A FULL PANEL.

LENGTH: 30-150 FEET
9-45 METERS

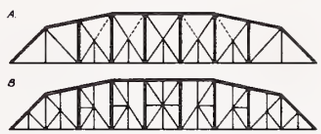


BOWSTRING ARCH-TRUSS

1840 - LATE 19TH CENTURY

A TIED ARCH WITH THE DIAGONALS SERVING AS BRACING AND THE VERTICALS SUPPORTING THE DECK.

LENGTH: 50-130 FEET
15-40 METERS



CAMELBACK

WITH SUBDIVIDED PANELS
LATE 19TH-EARLY 20TH CENTURY

A. A PENNSYLVANIA TRUSS WITH A POLYGONAL TOP CHORD OF EXACTLY FIVE SLOPES
B SAME AS A. WITH HORIZONTAL STRUTS.

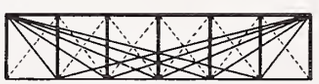
LENGTH: 100-500 FEET
30-150 METERS

SCHWEDLER

LATE 19TH CENTURY

A DOUBLE INTERSECTION PRATT POSITIONED IN THE CENTER OF A PARKER.

LENGTH: 100-300 FEET
30-90 METERS



BOLLMAN

1852 - MID-LATE 19TH CENTURY
(RARE)

VERTICALS IN COMPRESSION, DIAGONALS IN TENSION. DIAGONALS RUN FROM END POSTS TO EVERY PANEL POINT.

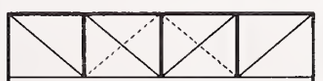
LENGTH: 75-100 FEET
23-30 METERS

BURR ARCH TRUSS

1804-LATE 19TH CENTURY
(WOOD)

COMBINATION OF A WOODEN ARCH WITH A MULTIPLE KING POST. (ARCH ALSO COMBINED WITH LATER WOODEN TRUSSES).

LENGTH: 50-175 FEET
15-50 METERS



TRUSS LEG BEDSTEAD

LATE 19TH-EARLY 20TH CENTURY

A PRATT WITH VERTICAL END POSTS IMBEDDED IN THEIR FOUNDATIONS.

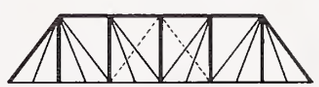
LENGTH: 30-100 FEET
9-30 METERS

WADDELL "A" TRUSS

LATE 19TH-EARLY 20TH CENTURY

EXPANDED VERSION OF THE KING POST TRUSS, USUALLY MADE OF METAL

LENGTH: 25-75 FEET
8-23 METERS



KELLOGG

LATE 19TH CENTURY

A VARIATION ON THE PRATT WITH ADDITIONAL DIAGONALS RUNNING FROM UPPER CHORD PANEL POINTS TO THE CENTER OF THE LOWER CHORDS.

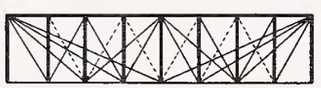
LENGTH: 75-150 FEET
23-30 METERS

K-TRUSS

EARLY 20TH CENTURY

SO CALLED BECAUSE OF THE DISTINCTIVE OUTLINE OF THE STRUCTURAL MEMBERS.

LENGTH: 200-800 FEET
60-240 METERS



FINK

1851 - MID-LATE 19TH CENTURY
(RARE)

VERTICALS IN COMPRESSION, DIAGONALS IN TENSION, LONGEST DIAGONALS RUN FROM END POSTS TO CENTER PANEL POINTS.

LENGTH: 75-100 FEET
23-45 METERS

TOWN LATTICE

1820 - LATE 19TH CENTURY
(WOOD)

A SYSTEM OF WOODEN DIAGONALS WITH NO VERTICALS. MEMBERS TAKE BOTH COMPRESSION AND TENSION.

LENGTH: 50-220 FEET
15-66 METERS

PARKER

MID-LATE 19TH-20TH CENTURY

A PRATT WITH A POLYGONAL TOP CHORD

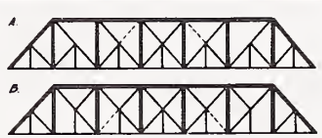
LENGTH: 40-250 FEET
12-75 METERS

WICHERT

1932 - MID-LATE 20TH CENTURY

IDENTIFIED BY A CHARACTERISTIC PIN-CONNECTED SUPPORT SYSTEM OVER THE PIERS. TRUSS IS CONTINUOUS OVER PIERS.

LENGTH: 400-1000 FEET
122-305 METERS



BALTIMORE (PETIT)

1871 - EARLY 20TH CENTURY

A. A PRATT WITH SUB-STRUTS.
B. A PRATT WITH SUB-TIES

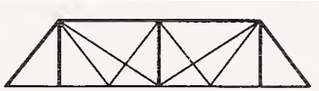
LENGTH: 250-600 FEET
75-180 METERS

WARREN

1848 - 20TH CENTURY

TRIANGULAR IN OUTLINE. THE DIAGONALS CARRY BOTH COMPRESSIVE AND TENSILE FORCES. A "TRUE" WARREN TRUSS HAS EQUILATERAL TRIANGLES.

LENGTH: 50-400 FEET
15-120 METERS



STEARNS

1890 - EARLY 20TH CENTURY

SIMPLIFICATION OF FINK TRUSS WITH VERTICALS OMITTED AT ALTERNATE PANEL POINTS.

LENGTH: 50-200 FEET
15-60 METERS

TRUSSES

A STUDY BY THE

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HISTORIC AMERICAN ENGINEERING RECORD
SHEET 2 OF 2 SHEETS

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